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細胞質雄不稔性粳稻之稔性恢復系選育[1]

曾 東 海[2]

摘要 以粳型細胞質雄不稔系臺農 67(WA) A及臺農 67(R)A 爲母本，與臺農秈育 91、169、175、176、178 等秈型恢復系雜交，探討恢復基因在其自交及回交後代的表現，以期育成粳型細胞質雄不稔性的稔性恢復系，供粳稻雜種品種育種之需。試驗結果：粳稻不稔系與秈型恢復系的雜種 F_1 稔實率皆低於50%，其 F_2 的稔實率分佈偏向低稔實，但仍有6～23%之個體稔實率超過70%。自 F_2 選拔高稔實單株，其 F_3 有12～46%之個體稔實率超過70%，顯示選拔具有某種程度的效果。選高稔實個體，再與粳稻臺農67號回交，其雜種F_1稔實率，隨回交次數而更偏向低稔實。從 $(F_2)BC_1F_1$ 選拔高稔實單株之 $(F_2)BC_1F_2$ 族羣，有19～53%之個體稔實率超過70%，顯示其選拔效果較比從 F_2 族羣選拔之效果大。臺農67(R)A／臺農秈育169組合之各世代，皆有較高比例之高稔實個體，顯示其恢復基因之作用較強。正常花粉率與稔實率相關極顯著。從 $(F_2)BC_2F_1$ 及 $(F_2)BC_1F_2$ 世代選拔高稔實單株，以系譜法繼續選育中。

提高作物的產量及品質，降低生產成本，爲栽培者之願望，也是研究人員的目標，而品種改良是達成目標之主要方法。自雜種 F_1 具有雜種優勢被發現後，利用雜種優勢從事品種改良，即被廣泛地應用，在玉米、高粱等異交或常異交作物，早已著有績效。

自交作物欲達到利用雜種優勢育種，則必須具有雄不稔或自交不稔，才能達到經濟栽培之目的[6,18]，利用細胞質雄不稔性的不稔系、維持系及恢復系等三系統育成的雜種水稻品種，在中國大陸已被廣泛地從事經濟栽培，其產量較普通品種增產20～30%，證實了水稻利用雜種優勢的可行性[9,15,16]。

水稻是本省的主要農作物，因此各改良場所莫不積極地從事品種改良及其他有關之試驗研究工作，本所除以傳統之方法進行水稻品種之雜交選育外，尙從事雜種品種之探討，經過多年來的研究，在秈稻方面，早期雖已找到較普通品種增產的雜種組合[2,5,12]，但因不稔系或稔性恢復系都是熱帶性品種，對本省環境不儘適合，造成不穩定，而未能實際利用。最近仍進行育成品系的稔性恢復基因的篩檢，並將雄不稔性細胞質轉移到本省育成的優良品系[4]，此工作即將完成，預期不久的將來，秈稻雜種品種，即可達到經濟栽培的目標。

目前本省水稻栽培，90%以上是屬於粳稻品種，因此粳稻品種改良備受關切，在粳稻利用雜種優勢方面，雖已成功地育成細胞質雄不稔系，但多年來從事粳稻細胞質雄不稔性恢復系的篩檢，其雜種 F_1 的稔實率皆低於50%，未發現任何品種（系）具有粳稻細胞質雄不稔性之恢復作用[1,4]，致使粳稻無法利用雜種優勢。筆者等仍利用回交與自交並行的方法，將存在秈稻的稔性恢復基因轉移到粳稻細胞質雄不稔系，探討恢復基因在不同世代的表現，以瞭解秈稻的稔性恢復基因轉移到粳稻的可行性

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，此工作現仍繼續進行中。爰將三年來的初步結果，整理發表，以就正於方家，並供爾後工作之參考。

材料與方法

一、試驗材料

稉稻細胞質雄不稔系，臺農 67(WA)A 及臺農 67(R)A 爲母本，秈型稔性恢復系，臺農秈育91、114、119、120、169、175、176、177、178、179等10品系爲父本，臺農67號爲輪迴親。

臺農 67(WA)A 及臺農 67(R)A 是本所育成的稉型細胞質雄不稔系，分別具有 WA 型及 R型雄不稔性細胞質，而其核型則與臺農67號相同。

臺農秈育91、169、175、176及178等五品系，爲本所育成具有抗病抗蟲的秈稻優良品系，經以珍汕 97A 爲母本篩檢的結果，證實這五品系皆具有恢復珍汕 97A 細胞質雄不稔系的稔性恢復能力。

二、試驗方法

民國74年第一期作，以臺農 67(WA)A 及臺農 67(R)A 等二個稉稻細胞質雄不稔系爲母本，臺農秈育91號等對珍汕 97A 具有雄不稔性稔性恢復作用的10個秈稻品系雜交，第二期作調查各組F_1之稔實率。就 WA 及 R 型細胞質分別選 F_1 稔實率較高的3個組合爲材料，於75年第一期作以單本植栽培 F_2 集團，並調查其正常花粉率及種子稔實率。從 F_2 集團中選出正常花粉率較高的單株，以這些單株爲母本，與臺農67號雜交並保留該株二、三穗自交，得到 $(F_2)BC_1F_1$ 及 F_3 之種子，並於收穫時調查其自交穗之稔實率。其他單株於收穫期，各採一穗進行稔實率調查，由其中選出稔實率較高者爲 F_3 系統。

民國75年第二期作，以系譜法栽培 $(F_2)BC_1F_1$ 及 F_3，單本植，每系統種植三行，每行16株，行株距 25×20cm。並將材料分爲兩組，(1)爲 F_2 單株經回交同時得到 $(F_2)BC_1F_1$ 及 F_3 種子的系統，採用併對種植，即單號爲 F_3 系統，雙號爲同一來源的 $(F_2)BC_1F_1$。(2)爲 F_2 單株未經回交，只得到 F_3 的系統。於抽穗期檢視 $(F_2)BC_1F_1$ 材料的花粉，選擇花藥深黃色，飽滿正常的單株，以這些單株爲母本，再與臺農67號雜交，並保留該株二、三穗自交，得到 $(F_2)BC_2F_1$ 及 $(F_2)BC_1F_2$的種子。其他材料則於收穫期，採單穗調查其稔實率，第一組材料每株皆調查，第二組材料則只調查中間行的15株。

民國76年第一期作，採用相同的方法栽培 $(F_2)BC_2F_1$ 及 $(F_2)BC_1F_2$，並於收穫期採單穗，調查各株之稔實率，選出稔實率較高的單株，成立 $(F_2)BC_1F_2$ 及 $(F_2)BC_2F_3$ 系統。這些系統於民國77年第一期作，以系譜法繼續調查選育中。

結果與討論

一、各世代之稔實率的變異

各組合雜種 F_1、F_2 及 F_3 等三世代之稔實率分佈列於表1，雜種 F_1 單穗之稔實率最低爲15.42%、最高爲73.24%，F_2 稔實率之分佈極廣，自0%～98%各等級皆有，而偏向低稔實。從 F_2 選拔高稔實單株，其 F_3 的稔實率分佈；低稔實的頻度降低，高稔實的頻度增加，組合間的趨勢相似，但因組合不同而有明顯的差異。臺農67(WA)A／臺農秈育91之雜種 F_1 稔實率介於15.42%～40.72%，平均爲28.09%，其 F_2 集團因種子發芽率之關係，只有128單株，其稔實率介於0.23～83.44%，平均爲19.98%，由其中選出19單株，成立 F_3 系統，系統平均稔實率介於10～72%，而單株之稔實率則介於0～98%，總平均之稔實率爲37.6%。臺農 67(WA)A／臺農秈育169之雜種 F_1 稔實率介於 21.05～56.41%，平均爲39.74%，其 F_2 共調查371株，其稔實率介於0～91.13%間，平均爲40.25%，本組合計選出91單株，成立 F_3 系統，系統平均稔實率介於21～79%，而單株之稔實率則介於0～98%，總平均之稔實率爲51.2%。臺農 67(WA)A／臺農秈育178之雜種 F_1 稔實率介

於21.57～40.98%，平均爲29.42%，其 F_2 計調查 353株，其稔實率介於 0.37～95.63%，平均爲42.80%，選出高稔實率之90單株，成立 F_3 系統，系統平均稔實率介於 7～88%，而單株稔實率介於0～98%，總平均51.47%。臺農67(R)A／臺農秈育169之雜種 F_1 稔實率介於 34.52～73.24%，平均爲57.73%，其 F_2 計調查 699株，其稔實率介於 0～94.27%，平均47.84%%由此組合選出 121單株成立 F_3 系統，其系統平均稔實率介於21～92%，而單株稔實率介於 0～98%，總平均62.1%。臺農 67(R)A／臺農秈育175之雜種 F_1 稔實率介於 32.12～63.80%，平均 47.19%，其 F_2 計調查612株，其稔實率介於 0～96.14%，平均37.78%，選出115單株成立 F_3 系統，其系統平均稔實率介於17～81%間，單株稔實率介於 0～98%，總平均53.9%。臺農 67(R)A／臺農秈育176之雜種 F_1稔實率介於 23.61～53.2%，平均41.27%，其F_2計調查492株，其稔實率介於 0～93.42%，平均34.54%，本組合選出 93單株，成立 F_3 系統，其系統平均稔實率介於 16～73%，而單株稔實率介於 0～90%，總平均46.2%。

臺農秈育91等秈型細胞質雄不稔性稔性恢復系，對珍汕 97A 等秈型細胞質雄不稔系顯現具有顯性恢復基因[3]，且臺農 67號與臺農秈育 91、169、175 號雜交並無或只有輕微的雜種不稔性之現象，

Table 1. Frequency distribution of spikelet fertility of F_1, F_2 and F_3 from the crosses between Japonica CMS lines and Indica restorer lines

Cross	Generation	Number of offsprings plants with fertility rate of											Average fertility rate (%)
		0—10	11—20	21—30	31—40	41—50	51—60	61—70	71—80	81—90	91-100	Total	
TNG67(WA)A /TNGSY91	F_1	0	2	3	4	1	0	0	0	0	0	10	28.09
	F_2	66	20	9	8	7	8	3	6	1	0	128	19.98
	F_3	71	30	17	24	28	41	27	18	12	3	271	38.11
TNG67(WA)A /TNGSY169	F_1	0	0	3	1	5	1	0	0	0	0	10	39.74
	F_2	68	49	33	34	33	52	43	35	22	2	371	40.25
	F_3	165	82	65	99	111	191	262	213	126	41	1,355	51.75
TNG67(WA)A /TNGSY178	F_1	0	0	7	2	1	0	0	0	0	0	10	29.42
	F_2	76	28	30	29	29	38	52	44	21	6	353	42.80
	F_3	148	86	82	111	152	172	176	199	154	57	1,337	51.47
TNG67 (R) A /TNGSY169	F_1	0	0	0	1	0	4	4	1	0	0	10	57.73
	F_2	66	63	66	64	73	108	99	87	53	20	699	47.84
	F_3	80	74	76	97	117	237	293	341	325	174	1,814	62.59
TNG67 (R) A /TNGSY175	F_1	0	0	0	2	5	2	1	0	0	0	10	47.19
	F_2	109	91	74	70	55	64	62	54	23	10	612	37.78
	F_3	143	84	111	133	206	196	271	294	214	68	1,720	54.49
TNG67 (R) A /TNGSY176	F_1	0	0	3	1	4	2	0	0	0	0	10	41.27
	F_2	124	53	43	56	67	64	48	27	9	3	494	34.54
	F_3	135	121	123	120	171	216	269	190	47	2	1,394	46.77
Total	F_1	0	2	16	11	16	9	5	1	0	0	60	40.57
	F_2	509	304	255	21	264	334	307	253	129	41	2,657	39.98
	F_3	742	477	474	584	785	1,053	1,298	1,255	878	345	7,891	57.27

而在本試驗之結果，因有細胞質雄不稔性參與，其雜種 F_1 的稔實率偏低，可能尙有其他基因會影響恢復基因的作用，Rf 基因無法完整表現。臺農67號／臺農秈育178號的雜種 F_1 的稔實率只有15%，顯示具有秈稉雜交的雜種不稔性。因此臺農 67(WA)A 與臺農秈育178號雜種 F_1 的低稔實率，可能係受到雙重影響。

秈型細胞質雄不稔性稔性恢復基因，對稉型細胞質雄不稔系的稔性恢復作用，就本試驗之結果而言，在 F_1 及 F_2 世代是否受秈稉雜交的雜種不稔性影響較不明顯（表1），而從 F_2 選出高稔實率的單株，成立 F_3 系統，在 F_3 世代則可明顯地看出雜種不稔性的影響，臺農67(WA)A 與臺農秈育178號因具有秈稉雜交的雜種不稔性，雖然從其F_2選出之90單株的稔實率皆超過50%，平均爲74.13%，比從臺農 67(WA)A／臺農秈育 178號組合選出者爲佳，但其 F_3 的稔實率分佈，却有較多的比例是低於50%，平均值亦略低（表2），顯示在 F_3 明顯地受雜種不稔性的影響。

Table 2. Frequency distribution of spikelet fertility of mean from F_3 lines and parent (F_2) from the crosses between Japonica CMS lines and Indica restorer lines

Cross	Generation	Number of parents and F_3 lines with fertility rate of											Average fertility rate (%)
		0—10	11—20	21—30	31—40	41—50	51—60	61—70	71—80	81—90	91—100	Total	
TNG67(WA)A /TNGSY91	Parent (F_2)	0	0	0	0	1	8	3	6	1	0	19	63.89
	Line (F_3)	0	5	1	3	6	2	1	1	0	0	19	38.11
TNG67(WA)A /TNGSY169	Parent (F_2)	0	0	0	0	1	18	25	24	21	2	91	70.88
	Line (F_3)	0	0	6	19	12	24	22	8	0	0	91	51.75
TNG67(WA)A /TNGSY178	Parent (F_2)	0	0	0	0	0	7	23	35	19	6	90	74.13
	Line (F_3)	1	1	6	14	21	18	14	11	4	0	90	51.47
TNG67 (R) A /TNGSY169	Parent (F_2)	0	0	0	1	0	14	13	33	48	12	121	77.35
	Line (F_3)	0	0	3	6	16	20	35	29	11	1	121	62.59
TNG67 (R) A /TNGSY175	Parent (F_2)	0	0	0	0	2	27	26	32	20	8	115	70.48
	Line (F_3)	0	5	4	9	22	27	31	15	2	0	115	54.49
TNG67 (R) A /TNGSY176	Parent (F_2)	0	3	1	1	5	28	26	19	8	2	93	63.15
	Line (F_3)	0	1	11	18	28	16	15	4	0	0	93	46.77
Total	Parent (F_2)	0	3	1	2	9	102	116	149	117	30	529	67.36
	Line (F_3)	1	12	31	69	105	107	118	68	17	1	529	57.27

在 F_2 族羣選拔高稔實率單株，成立 F_3 系統，其稔實率再呈現分離現象，雖然其稔實率分佈的極爲廣泛，但與 F_2 族羣比較起來，低稔實率的頻度降低了，而高稔實率的頻度增加了，從 F_2 選出單株的稔實率與 F_3 系統平均稔實率，進行相關分析的結果，二者的相關係數，除臺農 67(WA)A／臺農秈育91組合外，其餘5組合都達極顯著。雖然 F_3 族羣的稔實率平均值，比其親本（選出之 F_2）的平均值低，但 F_3 的平均值及稔實率超過70%的單株比例的高低，與所選出的 F_2 單株的平均稔實率有密切的關係，其順位幾乎完全一致（表2）。顯示拔具有效果，六組合的趨勢皆相似，唯組合間的頻度變異略有差異，稔實率超過70%的頻度 F_3 比 F_2 增加最多的是臺農 67(R)A／臺農秈育

169，增加23.4%，最少的臺農 67(WA)A／臺農秈育91只增加6.6%。

Table 3. Freqency distribution of spikelet and pollen fertility of F_2 from the crosses between Japonica CMS lines and Indica restorer lines

Cross		Number of F_2 plants with fertility rate of										
		0—10	11—20	21—30	31—40	41—50	51—60	61—70	71—80	81—90	91-100	Total
TNG67(WA)A /TNGSY91	Seed	38	9	3	3	1	2	1	0	1	0	58
	Pollen	43	2	1	4	3	2	1	1	1	0	58
TNG67(WA)A /TNGSY169	Seed	2	3	0	3	1	2	3	0	0	0	14
	Pollen	1	1	2	1	1	2	2	1	3	0	14
TNG67(WA)A /TNGSY178	Seed	33	14	11	13	9	10	24	13	5	3	135
	Pollen	50	18	22	12	6	7	8	6	5	1	135
TNG67 (R) A /TNGSY169	Seed	4	2	6	4	5	13	7	8	4	1	54
	Pollen	1	1	0	0	3	0	2	6	9	32	54
TNG67 (R) A /TNGSY175	Seed	18	5	8	5	1	4	2	3	0	0	46
	Pollen	4	2	4	3	5	2	3	4	6	13	46
TNG67 (R) A /TNGSY176	Seed	18	11	6	8	10	5	2	3	0	1	64
	Pollen	7	0	5	3	7	1	1	5	18	17	64
Total	Seed	113	44	34	36	27	36	39	27	10	5	371
	Pollen	106	24	34	23	25	14	17	23	42	63	371

在 F_2 及 F_3 族羣中單株稔實率超過70%的株數或比例，以臺農 67(R)A／臺農秈育169組合最多或較高，單就 WA 型三組合來講稔實率超過 70%最多的是臺農 67(WA)A／臺農秈育 178，並不是臺農 67(WA)A／臺農秈育169。在 F_1、F_2 及 F_3 的高稔實率 (70%以上) 的比例，臺農67(R)A／臺農秈育 169比臺農 67(WA)A／臺農秈育169高 ，二組合之表現不同，而臺農 67(R)A／臺農秈育169與臺農67(WA)A／臺農秈育169兩組合除了細胞質不同外 ，其他遺傳背景完全相同 ，其稔實率的分離比却有明顯的差異。Virmani and Dalmacio [20] 以 IR46828A 及 IR54755A 篩檢恢復基因，亦得到類似的結果。由此結果顯示，可能尙有吾人未知的因素，會影響恢復基因的表現。

二、正常花粉率與種子稔實率的比較

於民國75年第一期作，於 F_2 集團抽穗開花期，於淸晨採集當日開花之小枝梗，以70%酒精固定，然後以 1 %碘碘化鉀 (I-KI) 溶液染色，再進行鏡檢。花粉粒大且外表光滑有染色的花粉爲正常花粉，不染色及皺縮變形的爲不正常花粉，計算正常花粉的百分比，調查結果與其種子稔實率列於表 3，本試驗調查 F_2 之正常花粉率的結果，顯示在兩雄不稔性細胞質類型間有明顯的差異，在 WA 型細胞質的組合，除了臺農 67(WA)A／臺農秈育 169 外 ，其正常花粉率明顯地偏低，而在 R型細胞質組合其正常花粉率高的比例較多， 顯示秈型恢復系對 R型稉稻細胞質雄不稔系的恢復性， 比對稉稻 WA 型細胞質雄不稔系佳，此結果與 F_2 及 F_3 族羣的稔實率超過70%的比例，R型組合比WA

型組合高的結果一致。

正常花粉率與種子稔實率進行相關分析的結果，各組合都達顯著或極顯著的正相關。六組合共調查371株，其相關係數數（r=0.4036）達極顯著水準，若扣除挖回玻璃室進行回交及自交之112單株，其相關係數（r=0.4752）亦達極顯著水準，而在秈型細胞質雄不稔系與恢復系雜交代，其花粉率與種子稔實率的相關係數高達 0.8885 (3)。此結果顯示稉型細胞質雄不稔系與秈型稔性恢復系的雜交後代，其種子稔實率受到更多的其他因子影響。這些干擾因子可能就是稉稻細胞質雄不稔性的稔性恢復系篩檢或選育困難的主因。

三、回交對稔實率的影響

民國75年第一期作，就 F_2 集團行花粉鏡檢，選擇正常花粉率較高的 112單株，挖回玻璃室，一方面做爲母本，與臺農67號雜交。另一方面保留該株 2～3 穗不處理，使其自交，而獲得同一來源之 $(F_2)BC_1F_1$ 及 F_3 種子，並就該自交稔實率及回交 F_1 種子數略作汰選，結果共得48組合，於第二期作栽培並調查全體之稔實率，其結果列於表 4，$(F_2)BC_1F_1$ 之稔實率低於20%的單株有 66.77%，而超過70%只有 4.3%，單株稔實率比 F_2 更偏向低稔實率，而同來源的 F_3 則有39.3%的單株稔實率超過70%，只有11.6%株稔實率低於20%，表現完全不同。

Table 4. Frequency distribution of spikelet fertility of F_3 and $(F_2)BC_1F_1$ from the crosses between Japonica CMS lines and Indica restorer lines

Cross	Generation	No. of F_3 and $(F_2)BC_1F_1$ plants with fertility rate of										
		0—10	11—20	21—30	31—40	41—50	51—60	61—70	71—80	81—90	91-100	Total
TNG67(WA)A /TNGSY169	F_3	10	10	7	7	16	15	24	30	26	17	162
	$(F_2)\ BC_1F_1$	65	21	13	9	8	14	18	17	5	2	172
TNG67(WA)A /TNGSY178	F_3	21	21	31	34	52	92	125	143	184	66	769
	$(F_2)\ BC_1F_1$	275	186	76	30	17	4	5	1	3	3	600
TNG67 (R) A /TNGSY169	F_3	44	54	51	47	66	81	94	108	102	47	694
	$(F_2)\ BC_1F_1$	231	106	66	29	25	15	13	19	9	6	519
TNG67 (R) A /TNGSY175	F_3	12	4	9	11	20	16	24	23	7	6	132
	$(F_2)\ BC_1F_1$	72	28	10	6	5	1	1	1	0	0	124
TNG67 (R) A /TNGSY176	F_3	36	31	28	29	41	45	65	49	13	1	338
	$(F_2)\ BC_1F_1$	76	94	60	37	21	11	9	4	4	0	316
Total	F_3	123	120	126	128	195	249	332	353	332	137	2,095
	$(F_2)\ BC_1F_1$	719	435	225	111	76	45	46	42	21	11	1,731

民國75年第二期作，就所培育之 $(F_2)BC_1F_1$ 材料，於田間檢視其花藥，選擇花藥深黃色，飽和正常的單株，挖回玻璃室再與臺農67回交，同時亦留 2～3 穗不處理，使其自交，獲得同一來源之 $(F_2)BC_2F_1$ 及 $(F_2)BC_1F_2$ 種子，並就該株自交稔實率及回交 F_1 種子數略作汰選共得24組合，於76年第一期作栽培並調查全體之稔實率，其結果列於表 5，再回交之 $(F_2)BC_2F_1$ 的稔實率低於20%的單株有 73.67%，只有 1.9% 的單株稔實率超過 70%，比 $(F_2)BC_2F_1$ 更偏於低結實率，而 $(F_2)BC_1F_2$ 的稔實率則出現二個峰度，一在 0～5 %另一在71～80%，雖然其峰度不高，但部份稔實（稔

實率21～70%）的頻度減少，而顯示出分向二端分佈的趨勢。

Table 5. Frequency distribution of spikelet fertility of $(F_2)BC_1F_2$ and $(F_2)BC_2F_1$ from the crosses between Japonica CMS lines and Indica restorer lines

Cross	Generation	Number of plants with fertility rate of										
		0—10	11—20	21—30	31—40	41—50	51—60	61—70	71—80	81—90	91-100	Total
TNG67(WA)A /TNGSY169	(F_2) BC_1F_2	4	7	4	6	9	11	7	30	24	0	102
	(F_2) BC_2F_1	54	18	13	9	7	2	1	1	0	0	105
TNG67(WA)A /TNGSY178	(F_2) BC_1F_2	33	15	19	25	22	19	25	32	39	15	244
	(F_2) BC_2F_1	124	71	14	6	4	1	0	1	1	0	222
TNG67 (R) A /TNGSY169	(F_2) BC_1F_2	62	32	20	28	23	11	16	17	17	13	239
	(F_2) BC_2F_1	143	47	17	14	4	9	4	4	4	2	248
TNG67 (R) A /TNGSY175	(F_2) BC_1F_2	3	1	3	2	5	6	8	8	0	0	36
	(F_2) BC_2F_1	24	1	3	3	2	0	1	1	0	0	35
TNG67 (R) A /TNGSY176	(F_2) BC_1F_2	36	17	7	14	12	12	16	24	20	0	158
	(F_2) BC_2F_1	81	19	22	25	21	5	6	1	0	0	180
Total	(F_2) BC_1F_2	138	72	53	75	71	59	72	111	100	28	779
	(F_2) BC_2F_1	426	156	69	57	38	17	12	8	5	2	790

回交是將某些特定基因導入某品種（系），而保存其他基因於該品種（系）的方法，本試驗採用回交與自交並行的辦法，進行 Rf 基因之轉移，調查 $(F_2)BC_1F_1$ 及 F_3 的稔實率，其結果；自 F_2 族羣選高稔實單株爲母本，與臺農67號回交，其 F_1 稔實率低於20%的比例高達66.7%，顯示回交使稔實率趨於劣勢。從 $(F_2)BC_1F_1$ 再與臺農67號回交，其 F_1 稔實率低於 20%的比例高達 73.67%，顯示再回交使稔實率更趨於劣勢，即低稔實率所佔的比例因回交次數而增加，而高稔實個體減少，其變異因組合不同而異。回交之雜種 F_1 其稔實率超過 70% 的比例，在 $(F_2)BC_1F_1$ 世代，以臺農 67 (WA)A／臺農秈育 169組合較多（13.95%），其次爲臺農67(R)／臺農秈育169組合（6.55%），而在 $(F_2)BC_2F_1$ 世代，則以臺農 67(R)A／臺農秈育169組合較多（4%），顯示臺農秈育169之恢復基因之作用較強。$(F_2)BC_1F_2$ 族羣有19～53%之個體稔實率超過70%，而 F_2 及 F_3 有6～23%及 12～46%之個體稔實率超過 70%（表 1 及表 5），$(F_2)BC_1F_2$ 族羣的高稔實率比例較 F_2 及 F_3 高，顯示自 $(F_2)BC_1F_1$ 選高稔實單株的選拔效果，比從 F_2 選拔之效果大。

自從1966年 Shinjyo 和 Omura [17] 首次證明栽培稻內確實存在著細胞質雄不稔及稔性恢復基因，而後許多學者不斷地探討細胞質雄不稔性及稔性恢復基因，發現不同來源之細胞質雄不稔性，並培育許多秈型細胞質雄不稔性及稔性恢復系統，供秈稻雜種品種育種之用，而在粳稻則未見有關報告 [8,9,16,19]。稻細胞質雄不稔性之稔性恢復基因的數目，因研究者所用材料不同，而有不同的結論。Huang 等 [13] 認爲是一對以上的顯性基因。Govinda Raj et al. [11] 認爲是一到三對基因控制。Fu [10], Lei et al. [14], Lin and Yuan [15], Young and Virmani [22] 等認爲是二對顯性基因。Yang and Lu [21] 指出 IR24 有 Rf_1Rf_1 和 Rf_2Rf_2 二對基因，Rf_1 的影響較 Rf_2 强。黃等 [3] 認爲係受到三到四對顯性基因控制。Cai and Wang [7] 報告指出，在 Nanzao、Zhonggangao、Erjiunan

、Kensulos 等 WA 型雄不稔系中，有一對抑制 Rf_1 或 Rf_2 恢復基因的顯性基因。這些研究皆以秈稻爲材料，未涉及秈稉雜交，影響稔性恢復基因的因素較少。本試驗係以秈稉雜交，因而有複雜的不同基因系統影響稔實率，致使細胞質雄不稔性之恢復機制比較難予解釋，唯由本試驗的結果：回交之雜種 F_1 稔實率顯著降低，可以了解臺農76號具有某抑制基因，影響恢復基因之作用。而雜種有複雜的不同基因系統影響稔實率，因此細胞質雄不稔性之恢復機制比較難予單獨研究，尙待進一步探討。

就本試驗的初步結果而言，欲將秈稻之細胞質雄不稔性的稔性恢復基因轉移到稉稻，不能採用連續回交，此乃回交會使稔實率降低，在選拔時容易疏忽，而以回交與自交並行或交替進行，細胞質雄不稔性的稔性恢復基因較易表現。以此方法選出285個 $(F_2)BC_2F_2$ 及 $(F_2)BC_1F_3$ 之系統，正在本所農場繼續調查選育中，待今年調查以後，將可獲得更多的訊息，了解秈稻之細胞質雄不稔性的稔性恢復基因，在稉型細胞質雄不稔系的表現。由本試驗從 F_2 及 $(F_2)BC_1F_1$ 選拔高稔實單株，其後代具有頗多的高稔實個體，顯示選拔有效，預料育成稉型細胞質雄不稔性的稔性恢復系是可行的。

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Breeding for Cytoplasmic Male Sterility Restorer Lines in Japonica Rice[1]

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Summary

Japonica cytoplasmic male sterile (CMS) lines, Tainung 67(WA)A and Tainung 67(R)A were used as maternal parents for crossing with Indica restorer lines Tainung Sen Yu 91, 169, 175, 176 and 178 to investigate the performances of restorer genes in the selfing and backcrossing offsprings. The purpose of this experiment was to develop Japonica CMS restorer lines for breeding Japonica hybrid rice varieties. Experimental results indicatedethat fertility rates of hybrid F_1 from crosses between Japonica CMS and Indica restorer lines were lower than 50%. Six F_2 populations showed a tendency of lower fertility rate. However, 6-23% of plants from the F_2 populations still possessed fertifity rate higher than 70%. Selection from such plants produced 12—46% of individuals in F_3 generations showing fertility rate above 70%. The results indicated that the selection in improving the fertility rate of Japonica CMS restorer lines was efficient to at least some extent. Selected high fertility plants from F_2 populations backcrossed to Tainung 67 showed a gradual decrease in feritilty rate when the backcrossing number increased. Selection of individuals from $(F_2)BC_1F_1$ with high fertility rate were able to produce 19—53% of plants possessing fertility rate over 70%. In other words, selectoin efficiency from backcross progenies was higher than that from the F_2 populations. Higher potency of restorer gene in Tainung Sen Yu 169 as the parent resulted in higher percentage of offsprings carrying high fertility rate, especially in the cross of Tainung 67(R)A× Tainung Sen Yu 169. Experimental results also showed a positive correlation between percentage of functional pollen and fertility rate. Selections from$(F_2)BC_2\ F_1$ and$(F_2)BC_1F_2$ populations are currently subjected to further tests by pedigree method in this laboratory.

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玉米種子接種單棲固氮菌對生育及產量的影響[1]

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摘要：以選擇性半固體培養基，篩選到本地玉米根圈之三株固氮活性較强及較耐高濃度銨之革蘭氏陰性短桿狀單棲固氮菌。以不同方法將固氮菌接種於玉米種子，配合不同氮素施用量，進行田間試驗，以觀察單棲固氮菌對玉米生長及產量的影響。74年秋作、75年春作及75年秋作試驗結果，顯示秋作玉米接種效應之產量比春作者好。玉米種子接種單棲固氮菌，不能顯著地增加產量，但能使玉米植株較高大而且抽絲期提早一週，氮素施用量超過 120公斤／公頃則化學氮肥之肥效蓋過玉米種子接種固氮菌之固氮效果，氮素施用量超過 180公斤／公頃時玉米產量就沒有顯著增產效果。玉米根部之固氮活性於幼苗期微弱，隨植株長大而增加，到抽絲期才較高。由於單棲固氮菌不能與玉米的鬚根產生共生或假共生作用，以及試驗結果接種單棲固氮菌於玉米種子，促進玉米生育及產量之功效有限，所以接種單棲固氮菌於禾本科玉米種子以增進作物產量之實際應用上有待突破。

爲了節省能源消耗及環境保護，利用各種土壤微生物協助作物獲取養分[7,14,15,17]是現代農業研究的目標之一。本試驗室在74年春作玉米，接種由巴西引進之單棲固氮菌 *Azospirillum* spp.[8,9]於玉米種子，效果不顯著，推究其原因可能是巴西玉米根圈分離出之 *Azospirillum* spp. 不能適應本地品種、土壤環境及氣候所致[5]。後來本試驗室進行以 N-free malate 之選擇性培養基，篩選本所玉米根部及附近土壤之單棲固氮菌，將篩選到高固氮活性之單棲固氮菌接種於玉米種子，初步田間試驗結果知道可使玉米植株較高大，吐絲期提早一週，但產量不能顯著增加，乃繼續篩選得到三株固氮活性較强及耐高濃度銨之革蘭氏陰性短桿狀單棲固氮菌，擬接種於玉米種子後播種，希望由固氮菌固定空氣中氮素，提供部分氮養分給玉米利用，以增進玉米生長、產量和減少化學氮肥的施用，節省生產成本和保護農業環境[11]。

材料與方法

一、單棲固氮菌之篩選：

由本所及附近玉米田取生長期中玉米根部，經切斷後放入半固體 N-free malate 選擇性培養基（表 1），繁殖四天後用平板劃線法分離純化出純菌，然後以乙炔還原法[1,12]測定其固氮活性，選出固氮活性較高之菌株將其接種於含 20ppm NH_4^+-N 之 malate 選擇性培養基中，亦用乙炔還原法測定固氮活性，以篩選出能耐高濃度銨又具有高固氮活性之菌株。

二、固氮菌之染色及觀察：

菌株於 N-free malate 選擇性半固體培養基中，經24小時培養，取半固體培養基上層白色菌液稀釋，稀釋菌液取一滴置於載玻片上，風乾或熱固定成菌膜，進行下列步驟染色[10]：

1.臺灣省農業試驗所　研究報告第 1481 號。本研究承行政院農業發展委員會補助，謹此致謝。

2.本所農業化學系研究員、助理研究員、助理研究員。臺灣省　臺中縣　霧峰鄉。

表1. N-free malate 選擇性培養基

Malic acid	5.0 g	KOH	4.5 g
K_2HPO_4	0.5 g	Agar	1.75 g
$MgSO_4 \cdot 7H_2O$	0.2 g	Biotin	0.1 mg
NaCl	0.1 g	Fe EDTA (1.6% w/v[a])	4.0 ml
$CaCl_2$	0.02 g	Bromothymol blue (0.5% w/v[b])	3.0 ml
$Na_2M_0O_4 \cdot 2H_2O$	0.002 g	pH	6.8
$MnSO_4 \cdot H_2O$	0.01 g		

a. Volume of water.
b. Volume of alcohol.

1.以 1 %結晶紫 (crystal violet) 浸滲載玻片上之菌膜 1 分鐘。

2.用間接水流 (Indirect stream of tap water) ，洗菌膜 2 秒鐘。

3.用碘及碘化鉀之混合液，浸滲菌膜 1 分鐘。

4.間接水洗菌膜 2 秒鐘，然後用吸水紙將水分吸走。

5.菌膜浸滲於95%酒精30秒，用吸水紙吸水。

6.以番紅染液 (Safranin O 2.5%) 浸滲菌膜10秒。

7.以間接水洗菌膜，直至流出液沒有顏色，用吸水紙吸乾水分。

將染色好的菌膜玻片置於顯微鏡下，以油鏡頭觀察菌之形態。

三、接種固氮菌於玉米種子，對玉米生長、產量影響之試驗：

(一) 菌種之製備：

由玉米根圈分離篩選固氮活性最高且耐銨態氮之三株固氮菌 ，在顯微鏡下之形狀 ，以及於 N-free malate 培養基平面培養之菌落的形狀、顏色等均相似 ，在試管上以半固體培養基培養之菌，族羣均生長於培養基表面之下，推測爲同一固氮菌，因此於 N-free malate 培養基培養三天後，相互混合當做種源。

(二) 田間試驗：

玉米供試品種爲臺農 351號，試驗採用裂區試驗設計，以固氮菌接種於玉米種子之方法爲主試因，氮肥施用量爲副試因，試驗處理有四重複，處理小區面積爲 $15m \times 6m = 90m^2$，玉米種子皆先催芽 1 天，每穴二粒玉米種子，每公頃施用150公斤 P_2O_5、100公斤 K_2O，磷肥用過磷酸鈣、鉀肥用氯化鉀、氮肥用尿素，依一般推薦方法進行田間管理。

1.74年秋作 (74年10月 5 日播種75年 2 月25日收穫，試驗圃爲本所21號田)，行株距75cm×25cm：

菌種接種於玉米種子方法：(1)拌播：每小區，泥炭土9.5公斤和菌種液6.3公升相互混合後和玉米種子攪拌。(2)浸種：玉米種子浸入菌種液中。(3)噴種：每小區噴 6.3公升菌種液。(4)對照：只播種玉米種子及噴同量未接菌種之培養液。每公頃氮素施用量：(1)25公斤。(2)75公斤。計 4 × 2 = 8 處理。

2.75年春作 (75年 3 月12日播種，6 月30日收穫，於本所63號田試驗) ，行株距75cm×25cm：

菌種接種於玉米種子方法：(1)拌種、(2)浸種、(3)噴種、(4)對照，此四種方法同74年秋作，(5)小區施9.5公斤泥炭土。每公頃氮素施用量：(1)30公斤、(2)60公斤、(3)120公斤、(4)180公斤。計 5 × 4 ＝20處理。

3.75年秋作(75年 9 月16日種，76年 2 月10日收穫，於本所21號田試驗，行株距75cm×25cm)；

菌種接種於玉米種子方法：(1)拌種、(2)浸種、(3)對照，此三種方法同74年秋作。每公頃氮素施用量：(1) 0 公斤、(2)30公斤、(3)60公斤、(4)120公斤、(5)180公斤、(6)240公斤，計 3 × 6 =18處理。

結果與討論

一、單棲固氮菌於顯微鏡下之外觀形態：

經乙炔還原法及革蘭氏染色法（Gram's stain method）染色篩選到之單棲固氮細菌，於光學顯微鏡之油鏡頭下，可以觀察到所篩選的固氮菌爲革蘭氏陰性菌（Gram's negative bacteria），短桿狀（圖 1 ）。此菌屬於半嫌氣菌（Faculative bacteria），於 N-free malate 半固體選擇性培養基之表面下，聚集生長，菌族羣呈現白色。

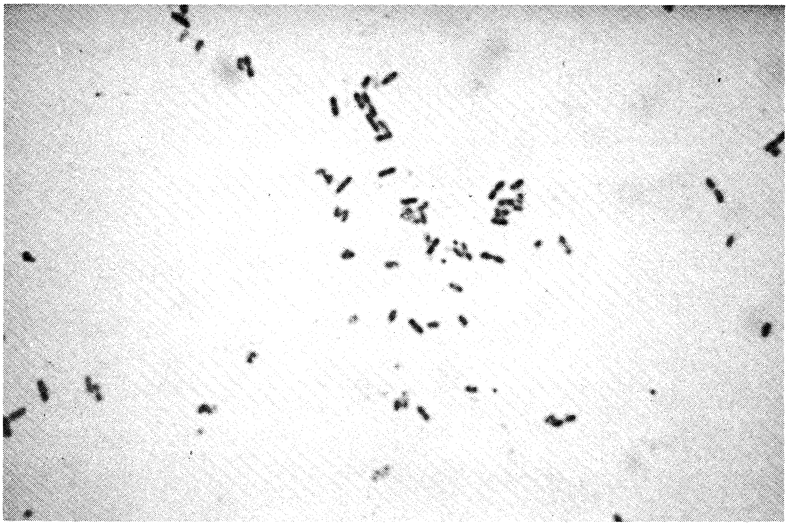

圖1. 由本所玉米根圈分離篩選所得之固氮活性較强及較耐高濃度銨之單棲固氮菌的顯微鏡下外觀形態（1000×）

二、玉米種子接種固氮菌對玉米生育及產量的影響：

由圖 2 、圖 3 、圖 4 可以知道氮素施用量若每公頃少於60公斤，玉米種子接種單棲固氮菌比不接種單棲固氮菌有較高的產量（$P<0.05$），若氮素施用量每公頃超過 120公斤，則接種單棲固氮菌之處理促進玉米產量之效果不顯著，但能使植株較高大，抽絲期提早一週。單棲固氮菌接種於玉米種子之方法對玉米產量的影響，以拌種處理和浸種處理最有利於玉米之生育及產量，其次爲噴種處理。因玉米幼苗期根系小，且根部分泌物少，提供固氮菌養分有限，所以固氮活性低，以氣相色層分析儀測定固氮活性，測値很小，接近於背景測値（Background value），隨著玉米漸漸長大，固氮活性漸漸增加，一直到玉米抽絲期，玉米根部之固氮活性才達到最高，顯示根圈之固氮菌族羣之消長及固氮活性受玉米植株生育之大小所影響，每公頃氮素施用量低於 120公斤時，拌種、浸種、噴種處理之玉米根系比對照處理之根系有較高的固氮活性（噴種處理每公頃施30公斤氮素者除外），顯示接種固氮菌於玉米種子可以增加玉米根系固氮活性（表 2 ），但每公頃氮素施用量高於 120公斤時，則接菌處理下之玉米根系固氮活性不比未接菌處理者高，表示每公頃氮素施用量超過 120公斤時，固氮菌固定氮素活性會受抑制，此時接種固氮菌於玉米種子以增進玉米根系固氮活性之效果不好。每公頃氮素施用量低於60公斤時，接種固氮菌處理之玉米產量高於未接菌者（$P<0.05$），可能與根系固氮活性較高有關（表 2 ）。拌種處理須要培養菌種外還須要將菌種液和泥炭土拌混成接種源，以及玉米種子和接種源攪拌後才能播種，較費工、費時。噴種處理，將菌種噴灑於玉米植穴之條溝中，菌種易於被土

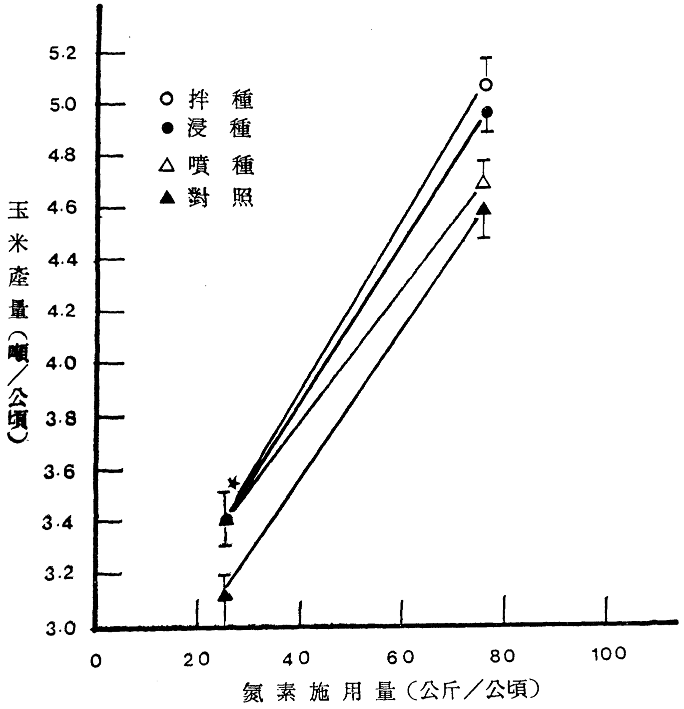

圖2. 固氮菌種接種於玉米種子之方法對玉米產量的影響(74年秋作)。＊：表示標準偏差。

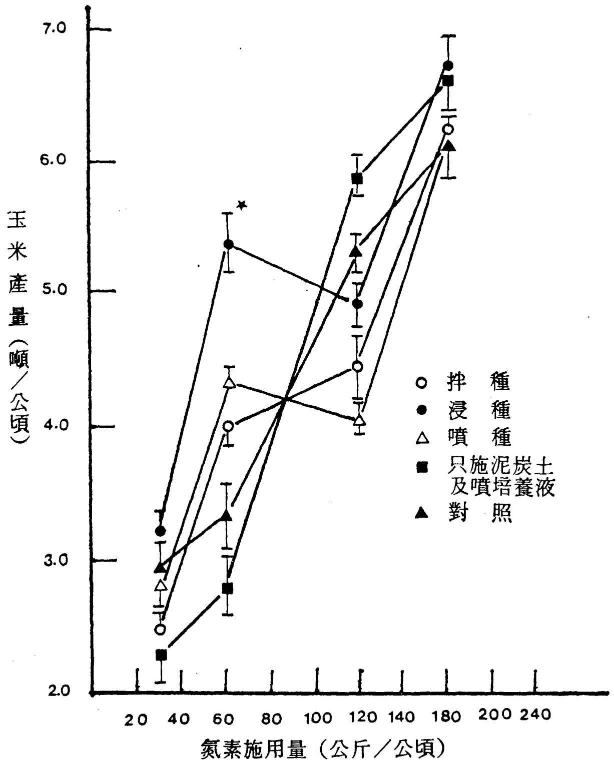

圖3. 固氮菌種接種於玉米種子之方法對玉米產量的影響(75年春作)。＊表示標準偏差。

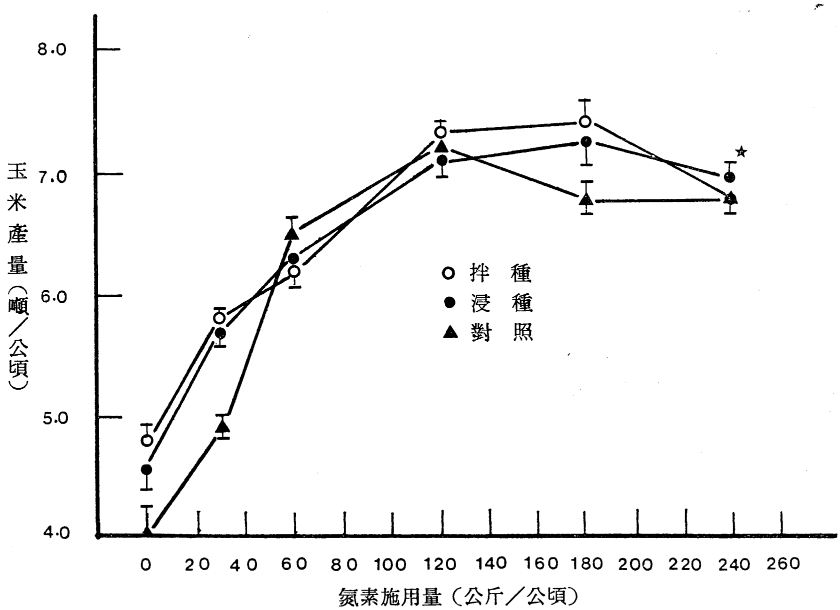

圖4. 固氮菌種接種於玉米種子之方法對玉米產量的影響（75年秋作）。＊：表示標準偏差。

表2. 抽穗初期時玉米根部固氮活性＊（n mole N_2 fixed/g fresh root day 75年春作）

菌種接種之方法	氮素施用量（公斤／公頃）			
	30	60	120	180
拌　種	131	171	55	17
浸　種	94	136	35	12
噴　種	33	89	34	23
只施泥炭土及噴培養液	43	103	32	13
對　照	36	73	3	20

＊ 三重複樣品測值之平均值。

壤吸附及因土壤乾燥而死亡或被土壤中之微小原生動物（Protozoa）所吞食，故菌種接種於玉米種子之效率差，而且噴灑工作亦相當麻煩。浸種處理，是將催芽後的玉米種子浸泡菌種液，可能使單棲固氮菌立即被吸附於幼根表面或潛入表皮，再播入田間，可提高菌種接種效率，促進玉米生長、產量之效果與拌種處理者相近，但比拌種處理省工（圖２、３、４）。單棲固氮菌雖然可以固定空氣中氮素而加以利用合成細胞成份，但以利用氮素肥料如尿素、硫酸銨等為優先，如果土壤中氮素肥料濃度高時則會抑制單棲固氮菌固定空氣中氮素之能力。[4] 。故由試驗結果（表２圖３、４）顯示當每公頃施用氮素量超過 120公斤時，則土壤中單棲固氮菌之固氮能力便受抑制，而不能有效地促進玉米之生長、產量，化學肥料氮素的肥效蓋過玉米種子接種單棲固氮菌之效果。只施泥炭土及噴施培養基（表１）於土壤中之處理，於每公頃氮素施用量低於 120公斤時，玉米產量較對照處理者低（圖３），其可能原因是泥炭土是一種含纖維素高之物質，碳氮比大於30，施加入土壤中可被土壤中之纖維分解菌如 *Chaetomium*、*Aspergillus*、*Trichoderma*、*Cytophaga*、*Cellulomonas* 等[4] 當做碳源，纖維分解菌活動增加而從土壤中吸收養分，與主作物競爭養分而影響玉米之生長與產量。豆科作物根瘤固氮與禾本科鬚根固氮之差別乃因根瘤菌可以和豆科作物形成共生根瘤，由豆科植物體將碳水化合物

如葡萄糖、蔗糖供給根瘤菌當做碳源以產生能源如ATP以及合成胺基酸所需碳架（Carbon skeleton）如 Oxaloacetate 、 Glutamate [4]，而根瘤固氮菌固定空氣中氮素形成胺基酸，部份自用，另一部份則經由共生根瘤供給植物利用，一般而言每固定空氣中氮素 1 mole 需要消耗 1.5moles 葡萄糖 [18]，單棲固氮菌固定空氣中氮素亦需消耗碳水化合物，每消耗 1g 葡萄糖可固定空氣中氮素 2至 3mg [4]。由於玉米為鬚根作物，單棲固氮菌未能與鬚根產生共生或假共生（Pseudosymbiosis，固氮菌潛伏於根部表面），而且鬚根之分泌物有限，不能供給大量固氮菌族羣繁殖所需之養分，因此即使接種高族羣密度之單棲固氮菌於玉米種子上，但終究會因為缺乏碳源，單棲固氮菌不能增加其族羣密度及固氮活性低，故不能如預期般地有效固定空氣中氮素，供給作物吸收利用 [6]。若單棲固氮菌先在實驗室大量培養後，再以適量之蔗糖或葡萄糖當做分散劑（Carrier），然後玉米種子在播種前和含有單棲固氮菌之分散劑互相攪拌後，一起施放入土壤中可增加固氮菌族羣繁殖時所需之碳源，或許可以增加土壤固氮活性，或土壤加施有機質以增進土壤中之碳源則比較能增進固氮活性有利於玉米之生長和產量。單棲固氮菌不能和作物根部形成共生狀態或假共生狀態，又單棲固氮菌於細胞內將空氣中的氮素固定為 NH_3, NH_3 和 $NADPH_2$ 及 α-ketoglutarate 形成 Glutamate [13,16], NH_3 和 Oxaloacetate 形成 Aspartate [4,13] 然後由 Glutamate 和 Aspartate 分別合成細胞內胺基酸，若要供給作物利用，則須要運出細胞體外，釋放於周遭環境中，但釋出之量有限，大部份還是留在細胞內，而且由細胞直接排出之胺基酸或由細胞死亡後所釋出之胺基酸或氮化合物，須由作物根部再吸收利用 [4]，若所釋出之胺基酸或氮化合物，不在植株根部伸展到的地方，則不能被作物吸收利用，不像根瘤共生固氮作用，豆科根部細胞可以在根內將根瘤菌固定氮素合成之 Glutamate 直接吸收轉換成豆科植物細胞內的胺基酸。又因接種單棲固氮菌於玉米種子費時、費工，接種固氮菌於玉米種子對於玉米生育及產量增加有限，因此非共生固氮菌在禾本科鬚根作物之實際應用還有待突破。

三、在接種單棲固氮菌之下玉米氮素適用量的探討：

74年秋作玉米，每公頃施用25公斤氮素時，對照處理與接種處理之玉米產量均無顯著差異（$P<0.05$），圖２）但接種單棲固氮菌於玉米種子處理之玉米產量比對照處理者高。每公頃施用75公斤氮素時，拌種處理之玉米產量與對照處理者可達顯著差異（$P<0.05$），浸種及拌種處理之玉米產量與對照處理者雖有差異，但統計上不顯著，但浸種處理之玉米生長較噴種處理者較佳。75年春作之試驗設計為探求接種固氮菌下適當氮素用量，故增加氮素用量處理。試驗結果，在接種固氮菌下隨氮素施用量愈高，大致上產量愈好（圖３），顯示玉米生育期所需之氮肥主要還是由肥料而來，由固氮菌固氮之貢獻很小。每公頃氮素施用量由30公斤增至60公斤，60公斤增至 120公斤，120公斤增至180公斤時，拌種處理下之玉米產量增加百分率分別為60%、10%、41%，浸種處理下之玉米產量增加百分率分別為69%、－９%、37%，噴種處理下之玉米產量增加百分率分別為54%、－７%、53%，只施加泥炭土及培養基處理下之玉米產量增加百分率分別為18%、58%、17%，對照處理下之玉米產量增加百分率分別為 18%、58%、17%，而浸種處理、噴種處理下氮素施用量於每公頃60公斤增至120公斤時，玉米產量則有減產現象，其原因可能是受75年春作時雨量太多所影響。75年秋作玉米，玉米種子接種固氮菌的方法為拌種、浸種、對照三處理，氮素施用量等級與75年春作相同，但增加 240Nkg/ha 處理，擬探討在高氮肥施用量及玉米接種固氮菌下是否對玉米之產量還會增產。試驗結果，在接種固氮菌處理下，隨氮素施用量愈高則產量亦愈好圖(４)，但是氮素施用量超過 180kg/ha 則玉米產量有減產的趨勢。每公頃氮素施用量由０公斤增至30公斤，30公斤增至 60公斤，60公斤增至120公斤，120公斤增至180公斤，180公斤增至240公斤時，拌種處理下之玉米產量增加百分率分別為21%、７%、18%、１%、－９%，浸種處理下之玉米產量增加百分率分別為９%、29%、13%、１%、－４%，對照處理下之玉米產量增加百分率分別為43%、14%、11%、、－７%、０%，在各不同氮素施用量下，菌種接種之方法以拌種比浸種效果好（圖４）。由上述結果顯示玉米種子接種單棲固氮菌處理下，每公頃氮素施用量介於60至120公斤時最能顯現出接菌效果，每公頃氮素施用量超過180公斤時

對玉產量的增加有限，而且可能減產，連氏曾測定玉米植株吸收三要素量（穀粒產量爲 6.5噸／公頃），N、P_2O_5、K_2O 分別爲120公斤、45公斤、100公斤至120公斤，而推薦中南部適當玉米氮肥用量爲165公斤（3.）。臺農351號玉米種子發芽後，幼苗生長與養分吸收均緩慢，但此期之生長卻十分重要，因爲平均每 3 天要長出一片新葉，而葉面積決定了玉米的生產量潛力，且植株生長旺盛根部之分泌物才能提供單棲固氮菌繁殖所需養分，若水分太多，土壤太潮濕，土壤通氣不良，則減低發芽率及抑制早期生長，也因而影響了根圈微生物固氮菌族羣的生長，而影響到每株穗數及每穗種子數、產量(2)，故玉米播種後30天內之土壤水分狀態，是影響玉米產量很重要的因素之一。74年秋作時，降雨量少，在玉米生育期間，雖然有高達 80mm 及 35mm 之遽雨性日降雨量，但只有 2 天而已，而且是在玉米種子播種後第80天、第130天（圖5.），75年秋作時，雖然播種後第 4 天有高達 92mm 日降雨量，第60天有 49mm 日降雨量（圖7.），但亦屬於遽雨性降雨量，雨水在很短時間就可以排掉，玉米田浸水時間很短。故74年、75年秋作玉米時，土壤狀態大部分時間是通氣良好，不會對根圈微生物、固氮菌族羣等造成逆境，亦不會對玉米的生長、產量造成阻礙性的影響。然而75年春作玉米時，玉米種子播種後除了 2 天沒有下雨，持續下了23天的雨，此段期間表土土壤呈現幾近飽和狀態，又播種第61天後亦連續下了幾近一個月的雨（5 月19、24及 6 月 2 、 3 、10除外，圖 6 ），使得75年春作時，玉米田表土之水分含量常保持於飽和或幾近飽和狀態，土壤通氣不良而缺氧，因土壤中氧的分壓低於1.5%會抑制作物生長[19]，造成種子發芽率不好，幼苗生長受抑制，又因爲固氮菌族羣之增殖須靠玉米根部分泌物之增加而增加[4]，當雨水多時玉米幼苗生育不好，根部之分泌物少，根圈之固氮活性亦因而減少，使得植株生長較緩慢，產量減少。74年秋作玉米、75年秋作玉米產量比75年春作玉米產量高的原因，可能是由上述春作、秋作降雨量分配型態不同、氣候不同、根圈微生物及固氮菌族羣之生長、病蟲害感染率不同等所造成的。在臺灣，春作期間恰好是春雨綿綿及梅雨季，對於旱作玉米而言是非常不利的生長抑制因素，再加上春作潮濕而易罹患病害，故75年春作玉米產量偏低。

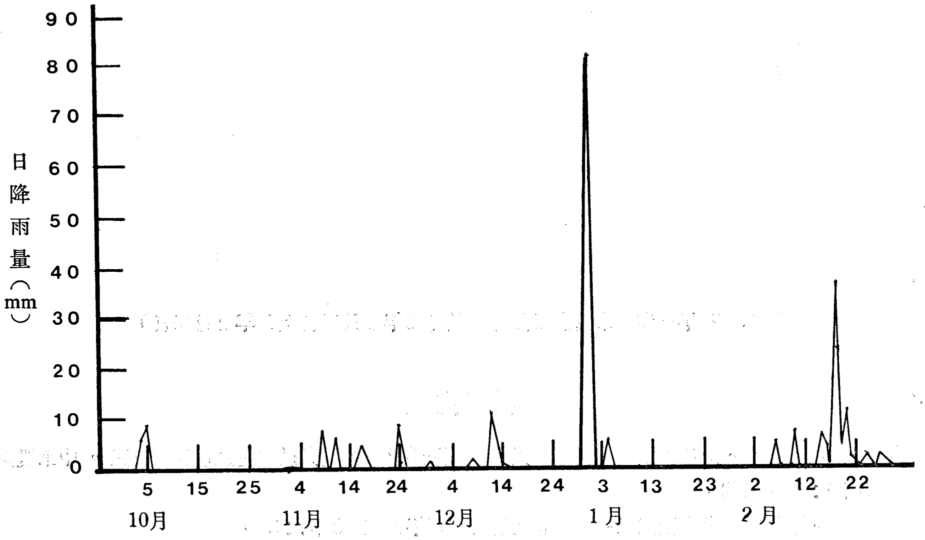

圖5. 74年秋作玉米時之田間降雨量（74年10月 5 日至75年 2 月25日）

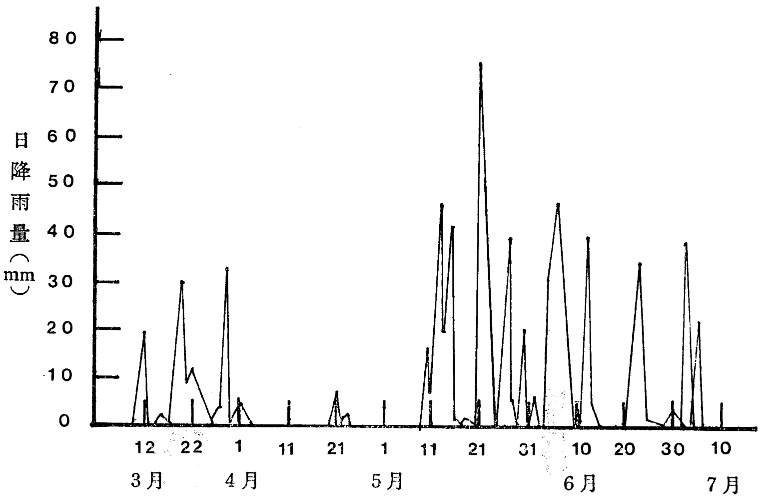

圖6. 75年春作玉米時之田間降雨量 (75年3月12日至75年6月30日)

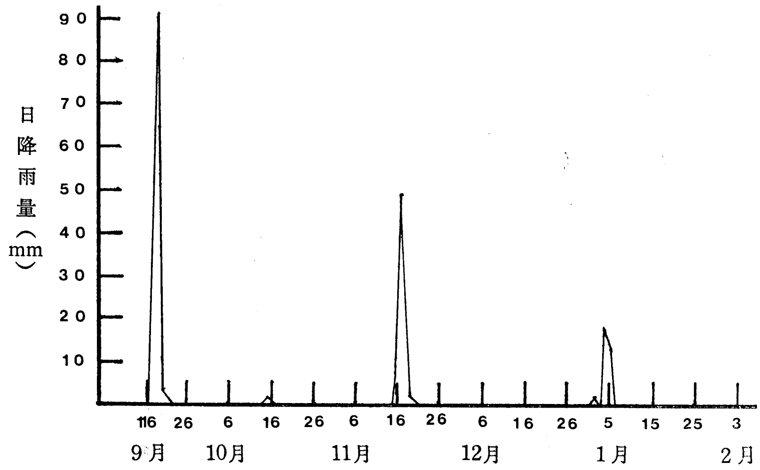

圖7. 75年秋作玉米時之田間降雨量 (75年9月16日至76年2月10日)

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The Effect of Inoculating Corn Seed with Free-Living Nitrogen-Fixing Bacteria on the Growth and Yield of Corn[1]

C. J. Lin, S. Y. Jane and H. Y. Kuo

Summary

Three strains of free-living nitrogen-fixing bacteria with high nitrogenase activity and ammonium tolerant ability were screened from corn root and its adjacent soil and cultured by N-free malate semi-solid selective medium. With different nitrogen application rates, the effect of inoculation of these free-living nitrogen-fixing bacteria on corn growth and yield were carried out in the field experiments during Autumn crop, 1985 to Autumn crop, 1986.

The results showed that corn seed inoculated with the free-living nitrogen-fixing bacteria could increase corn growth and promote the silking stage one week earlier, but could not significantly increase the grain yield of corn. When nitrogen application rates were above 120kg/ha, the plant growth and grain yield of corn were prevailed by fertilizer nitrogen than the effect of nitrogen-fixation; the suitable nitrogen application rate was 180kg/ha, the rewarding efficiency would be decreased if nitrogen application rates were above this level. Nitrogen-fixation rate of the excised young corn root was very low. Nitrogenase activity of the corn root was accompanied by the plant growth, and its highest activity was in the initial silking stage. Because free-living nitrogen-fixing bacteria can not build a symbiotic or pseudosymbiotic relationship with hairy roots of gramineous corn crop, and the results of the experiments showed that inoculation of the free-living nitrogen-fixing bacteria on corn seed could not significantly increase the corn yield; therefore the breakthrough the bottle neck of practical application of inoculating free-living nitrogen-fixing bacteria on gramineous crop remained to be studied.

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大豆粒型混合選種之評估[1]

林順福　魏趨開[2]

摘要　爲配合大粒高產之育種目標，本試驗將 HL-1×P58 及 KS8×T83-1 兩雜交組合 F_3 世代收穫之大豆種子，各別依粒型大小分羣，再評估各羣 F_4 世代植株農藝性狀，探討簡便、易行之粒型混合選種法施行效果，結果顯示選拔大粒型種子可顯著提高族羣平均百粒重，對於產量、株高、及植株乾重等影響，則因不同雜交組合而異。不同粒型後裔族羣具有相近百粒重變異範圍，及百粒重與其他性狀間之遺傳相關特性之維持，推測無論直接對粒型或間接對產量等其他性狀之改良，另一循環世代之粒型混合選種仍有採行價值。

混合育種法 (Bulk　method) 因在 F_2 至 F_5 世代間未有人爲選拔，可連續在不同季節繁殖，故一年可有 2～3 世代之推進，可把握育種時效，及具有天然淘汰之作用，簡便易行，爲本省最常採用之大豆育種法。但在各育種場所有限之經費、人力、物力及土地等條件下，以大豆平均具有40～50之繁殖倍率而言，及欲兼顧不同世代及不同雜交組合之後裔族羣，勢必無法將雜交後裔種子全部繁殖於田間。因此在有限之育種資源條件下，選擇有利育種目標之初期後裔族羣，遂爲大豆等後裔數量較多之自交作物，採用混合育種法時首需考慮之問題。

混合選種法 (Mass selection) 爲最原始，最簡便之自交作物改良法，但須在所欲改良性狀有較高遺傳率之條件下才有較佳效果[(4)]，由於大豆粒型大小具有較高遺傳率，且大豆粒型大小與產量之高低具有遺傳相關[(5,7,10)]，及因大粒型大豆外觀佳且種皮占粒重之相對比例較低，較適合於加工用途，故在結合高產及大粒型之育種目標下，若採行混合育種法，再配合粒型混合選種法取代一般逢機自混合族羣中選取適量之後裔，調整各世代、各組合族羣之大小，使在相同人力及土地投資下增加族羣有利基因頻度，無論直接對粒型改良或間接對產量等性狀改良將可能有所幫助，本試驗即針對粒型混合選種法使用於大豆育種之可行性加以探討。

材料與方法

試驗材料：

分別將包含本省較大粒型栽培品種 HL-1 (花蓮一號) 及 KS8 (高雄八號) 雜交親本之HL-1×P58 雜交組合 F_3 世代植株收穫之混合種子及 KS8×T83-1 雜交組合之 F_3 世代植株收穫之混合種子。以不同孔徑大小之篩網，篩選不同粒型大小之大豆種子，形成大粒型、中粒型及小粒型等三種粒型之族羣，由於 KS8×T83-1 後裔族羣小粒型種子個數甚少，故與中粒型種子合併，因此該雜交組合後裔僅分大粒及小粒兩種粒型之族羣，篩選標準及播種用各羣種子，如表 1，分羣後之種子於七十七年夏作在臺灣省農業試驗所試驗田種植，並調查主要農藝性狀。

1.臺灣省農業試驗所　研究報告第 1482 號。本文承蒙國立臺灣大學農藝系陳成教授、國立中興大學農藝系曾富生教授及本所呂秀英博士斧正，暨行政院農委會補助試驗經費，謹此誌謝。

2.本所農藝系助理及助理。臺灣省　臺中縣　霧峰鄉。

表1. 不同粒型大豆族羣之平均百粒重

Table 1. Seed weight (g/100-seed) of F_3 soybean populations as distributed by varying hole sizes.

Size class	Screen diameter hole (mm)	Hybrid combinaion	
		HL-1×P58	KS8×T83-1
Large	>6.40	22.58	23.17
Medium	5.66—6.40	17.66	18.25
Small	<5.66	13.91	13.66
Bulk		17.80	20.00

試驗方法及統計分析：

係依順序排列法將來自相同雜交組合之不同粒型族羣相鄰種植，行長三公尺，行距 x 株距爲55 x 15公分，每穴留兩株，由 HL-1×P58 組合不同粒型族羣中各逢機選取75株，KS8×T83-1組合不同粒型族羣中各逢機選取50株（邊行及邊株不取），以非配對 t 值法（Unpaired design）進行比較，而未經選拔之原始族羣平均百粒重，可由不同粒型後裔族羣所含個體數加權估算，即：

原始族羣之平均百粒重（Bulk）＝（大粒型族羣平均百粒重 x 大粒型族羣個體數 ＋中粒型族羣平均百粒重 x 中粒型族羣個體數＋小粒型族羣平均百粒重 x 小粒型族羣個體數）／（大粒型族羣個體數＋中粒型族羣個體數＋小粒型族羣個體數）此外爲探討粒型選種後對於不同族羣個體性狀間遺傳相關結構之影響，另進行不同粒型後裔族羣間百粒重與其他主要農藝性狀之相關值間差異顯著性測驗 [1]，公式如下：

$$\tau(z_1-z_2)=(z_1-z_2)/\sqrt{1/(n_1-3)+1/(n_2-3)}$$

式中

r_1 及 r_2 分別爲兩族羣百粒重與其他性狀間實測相關係數

z_1 爲 r 經 z 值轉換而來

z_2 爲 r_2 經 z 值轉換而來

n_1 爲計算 r_1 之變值個數

n_2 爲計算 r_2 之變值個數

$\sqrt{1/(n_1-3)+1/(n_2-3)}$ 爲 z_1-z_2 之標準偏差。

z 分布爲一常態分布

結果與討論

（一）粒型混合選種對於後裔族羣百粒重之影響：

HL-1×P58 及 KS8×T83-1 兩大豆雜交後裔 F_4 世代族羣經不同粒型之篩選結果，HL-1×P58 組合大粒型後裔族羣之平均百粒重爲 18.7g，較小粒型後裔族羣之平均百粒重爲 16.1g 顯著增加 2.6g, KS8×T83-1 組合大粒型後裔族羣之平均百粒重爲 15.9g，分別較中粒型及小粒型後裔族羣之平均百粒重顯著增加1.0及 1.7g，原始族羣之平均百粒重亦與中粒型一致（表 2），由此可見在雜交後裔混合種子施行粒型混合選種，對於族羣粒型之改良顯著有效。春作環境有利於大豆百粒重性狀表現，故春作大豆族羣平均百粒重大於夏作，若將春作篩選得種子在另一年度春作評估，則可減少期作與粒型交感作用之影響，而有較佳選拔效果。

Burris 等提出同一品種之大豆種子品質及粒型大小分布比例與播種種子大小無關 [2,3]，而本試

表2. 不同粒型後裔族羣之平均百粒重

Table 2. Seed weight (g/100-seed) of $F_{3:4}$ soybean populations obtained from mass selection for seed size

Seed class	Hybrid combinaion	
	HL-1×P58	KS8×T83-1
Large	15.9* a	18.7 a
Medium	14.9 b	
Small	14.2 b	16.1 b
Bulk	14.9	17.1

* Data in the same column followed by the same letter are not different at p=0.05.

驗兩雜交組合經粒型混合篩選後，不同粒型大小族羣間其粒型變異範圍並無太大差異（圖1），但就族羣內粒型大小頻度分布而言，KS8×T83-1 組合大粒型後裔族羣百粒重小於 18g 之個體僅占48.0%，但小粒型後裔族羣百粒重小於 18g 之個體已占74.7%，而 HL-1×P58 組合大粒、中粒及小粒

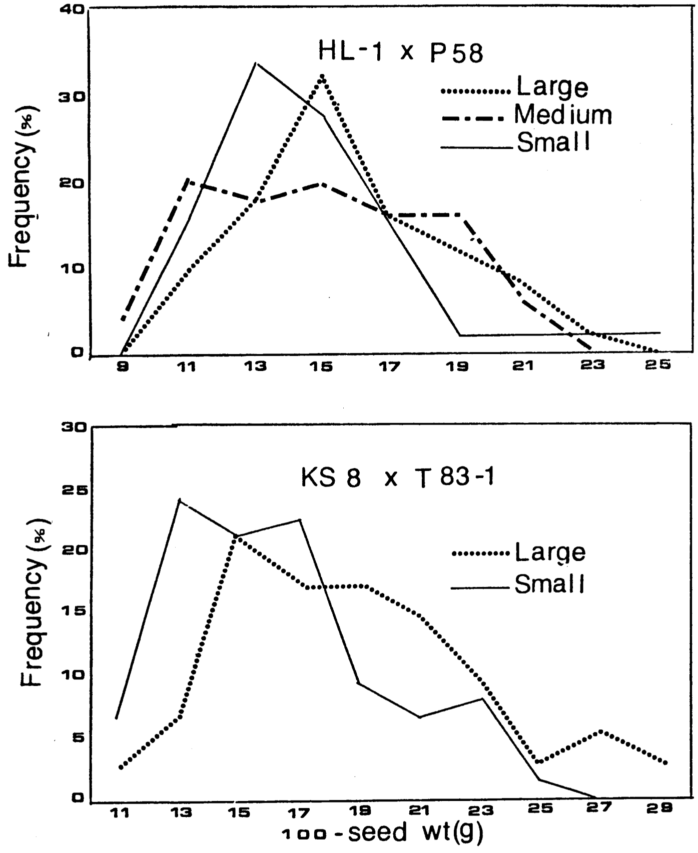

圖1. 不同粒型後裔族羣之百粒重分佈情形

Fig. 1. Frequency distribution of seed weight (g/100-seed) of $F_{3:4}$ soybean populations obtained from mass selection for seed size.

表3. 不同粒型後裔族羣之百粒重分佈累積頻率

Table 3. Cumulative frequency of seed weight (g/100-seed) of $F_{3:4}$ soybean populations obtained from mass selection for seed size.

Seed weight (g/100-seed)	Hybrid combinaion				
	HL-1×P58		KS8×T83-1		
	Large	small	Large	Medium	Small
<10	0.0	0.0	0.0	4.0	0.0
<12	2.7	6.7	10.0	24.0	16.0
<14	9.4	30.7	28.0	42.0	50.0
<16	30.7	52.0	60.0	62.0	78.0
<18	48.0	74.7	76.0	78.0	94.0
<20	65.3	84.0	88.0	94.0	96.0
<22	80.0	90.7	96.0	100.0	98.0
<24	89.3	98.7	98.0		100.0
<26	92.0	100.0	100.0		
<28	97.3				
<30	100.0				

型後裔族羣百粒重小於 14.0g 之個體則分別爲28%，42%，及50%（表 3），可知不同粒型之選拔結果將造成後裔族羣決定粒型之基因頻度改變。

（二）粒型混合選種對於後裔裔族羣產量及其他農藝性狀之影響：

Spaeth 和 Sinclair [3] 指出同一品種之種子大小變異無法由種子生長位置或種子生長期間所決定，且種子產量受種子大小及種子數目之補償作用所調整， Johnson 和 Luedders [9] 則指出同一品種之種子大小對其出土率及產量無顯著影響，而 Fontes 和 Ohlrogge [7] 亦研究相同品種之不同大小種子對產量及其他農藝性狀之影響，結果發現大粒種子具有較高產量、莢數、分枝數及較少之不孕株。以上報告均以相同基因型之不同粒型爲材料，本試驗則包含有不同基因型之混合族羣，經由粒型混合選種對於後裔族羣產量等農藝性狀之影響，如表 4 ，KS8×T83-1 組合大粒型後裔族羣之平均子粒產量，植株總乾物重及株高等性狀均顯著大於小粒型後裔族羣，大粒型後裔族羣之平均粒數（35.8）雖大於小粒型後裔族羣（32.5），但未達顯著差異水準， HL-1×P 58 組合大粒型後裔之植株總乾物重顯著大於中粒及小粒型後裔族羣，而大粒型後裔族羣之平均子粒產量、粒數等性狀雖大於中粒及小粒後裔族羣，但未達顯著差異水準，乃因在分羣前之 F_2 或 F_3 世代植株有百粒重與粒數間補償作用（粒大數少）或（粒小數多），可知粒型之混合選種雖可間接影響後裔族羣之總乾物重，但對於產量、粒數等性狀無顯著影響，即對粒型之選種無濟於產量之增進。故粒型選種對產量、粒數等性狀之影響則依雜交組合而不同。Simth 和 Weber [12] 及 Fehr 和 Weber [6] 選拔大粒及比重大之種子以提高族羣之平均蛋白質百分率， Fehr 和 Probst [5] 提出大豆種子大小與後裔之產量、種子百粒重及株高等有顯著之遺傳相關， Johnson [10] 等評估大豆各性狀之相關性時，提出較長之果莢生育期及較高百粒重等與高產有顯著遺傳相關， Hartwig 及 Edwards [8] 利用回交法轉移不同粒型特性至相同遺傳背景下，發現種子大小與產量無顯著相關，爲補救種子大小差異，具大粒種子之植株僅有輪迴親之56%果莢，而具小粒種子之植株則較輪迴親多55%果莢， Kenworthy 和 Brim [11] 依大豆產量進行三循環之輪迴選種結果，各循環均可增加大豆族羣之平均產量，而由產量之輪迴選種結果對於

表4. 不同粒型後裔族羣之平均株高、總乾物重、粒數及產量

Table 4. Plant height, total dry weight of plant, seed number, and yield of $F_{3:4}$ soybean populations obtained from mass selection for seed size

Seed class	Hybrid combinaion							
	HL-1×P58				KS8×T83-1			
	Plant height (cm)	Dry weight (g)	Seed number	Seed yield (g)	Plant height (cm)	Dry weight (g)	Seed number	Seed yield (g)
Large*	45.3 a	15.3 a	40.4 a	6.44 a	39.6 a	14.3 a	35.8 a	6.75 a
Medium	45.2 a	13.2 b	39.5 a	5.87 a				
Small	44.0 a	12.0 b	39.0 a	5.54 a	35.1 b	10.7 b	32.5 a	5.25 b

*The same as Table 2.

種子大小、油份百分比、蛋白質百分比等均未有顯著影響，可見粒型大小與其他性狀之相關性依試驗材料而有所差異，故依粒型間接選拔之反應不一致。因此，就本試驗材料而言，若以大粒高產爲育種目標，應以選拔大粒型種子而能提高族羣平均產量之 KS8×T83-1 雜交組合之後裔爲材料，若以小粒高產爲育種目標，則以粒型選拔族羣平均產量無顯著影響之 HL-1×P58 雜交組合之後裔族羣爲材料，對粒型之改良較爲有效。

（三）粒型混合選種對於後裔族羣性狀間遺傳相關結構之影響：

究竟有無進行另一循環粒型混合選種之價值，可就族羣之遺傳變異及性狀間之遺傳相關性進行探討，由圖1及表3，不同粒型後裔族羣之變異範圍並無明顯差異說明無論朝大粒或小粒型方向進行選拔均能維持粒型原有之遺傳變異，顯示直接對粒型改良而言仍具有第二循環粒型篩選之價值，另由不同粒型後裔族羣間百粒重與其他性狀之相關值顯著性測驗檢定經由粒型選拔後不同後裔族羣間之遺傳相關結構，即探討不同粒型之樣本族羣與未經篩選之原始族羣間遺傳組成差異，由表5，KS8×T83-1組合大粒型與小粒型後裔族羣間之百粒重與株高、乾物重、粒數及粒重間之相關值差異均未達顯著水準。而 HL-1×P58 組合除中粒型後裔族羣間之百粒重與株高之相關值有顯著差異外，其他大粒型與中粒型及小粒型後裔族羣間之百粒重與其他性狀之相關值均未達顯著差異水準，可見雖經粒型選拔造成產量，乾物重及株高等性狀顯著差異，但不同粒型間之百粒重與大多數性狀之遺傳相關結構並

表5. 不同粒型後裔族羣間百粒重與其他性狀相關值之差異顯著性測驗

Table 5. Significant test of correlation coefficients, involved in seed weight (g/100-seed) and other characters, between $F_{3:4}$ soybean populations obtained from mass selection for seed size.

Character	Hybrid combinaion			
	HL-1×P58			KS8×T83-1
	Large vs Medium	Large vs Small	Medium vs Small	Large vs Small
Plant height	1.80	−0.73	− 2.52*	0.18
Dry weight	1.02	1.16	0.14	0.96
Seed number	− 0.29	0.34	0.05	0.78
Seed yield	0.73	0.63	0.10	0.78

*; Significant at p=0.05.

未有顯著差異，即經粒型篩選後與未經選拔之原始族羣間之粒型與其他性狀之相關性相似，又由表 6，百粒重與其他性狀之相關分析顯示，KS8×T83-1 及 HL-1×P58 組合不同粒型之百粒重與產量間均有顯著或極顯著之正相關，又基於自交作物雜交後裔遺傳基因組合隨世代之增進而同結合個體比例遞增，使各性狀遺傳組成趨向於穩定之特性，可推測下一循環粒型混合選種仍有採行價值。

表6. 不同粒型後裔族羣百粒重與其他性狀間之相關值

Table 6. Correlation coefficients between seed weight and other characters of $F_{3:4}$ soybean populations obtained from mass selection for seed size.

Character	Hybrid combinaion				
	HL-1×P58			KS8×T83-1	
	Large	Medium	Small	Large	Small
Plant height	0.09	−0.29*	0.24	0.18	0.15
Dry weight	0.48**	0.25	0.21	0.51**	0.31**
Seed number	−0.01	−0.07	−0.08	0.13	0.01
Seed yield	0.52**	0.34*	0.36**	0.60**	0.43**

*, ** : Significant at p=0.05 and 0.01, respectively.

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Evaluation of Mass Selection by Seed Size in Bulk Soybean Populations[1]

S. F. Lin and C. K. Wey[2]

Summary

Two $F_{3:4}$ populations, i. e. HL-1×P58 and KS8×T83-1 hybrid combinations, were evaluated for response of mass selection for seed size in soybeans. Large seeds derived lines had significantly higher seed weight (g/100-seed) than that of medium and small seeds derived lines indicated that mass selection for seed size in bulk populations was effective. Large seeds derived lines had significantly high seed yield, total dry weight of plant, and plant height than those of small seeds derived lines only found in KS8×T83-1 hybrid combination.

With similar variation of seed weight and no significant difference among correlation coefficients between seed weight and other characters of various seed size derived lines, it is suggests that direct selection for seed size (in both hybrid populations) and indirect selection for seed yield, total dry weight of plant , and plant height (only in KS8×T83-1 hybrid combination) could be available in the next cycle of selection.

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Effect of Nitrate and Ammonium Nitrogen Sources on the Growth, Photorespiration, Dark Respiration and Activities of Related Enzymes in Wheat (*Triticum aestivum* L.)[1]

Dah-Jiang Liu[2]

Abstract: Wheat seedlings were grown hydroponically with 100 ppm of either nitrate or ammonium as the N source. Plant growth, CO_2 compensation concentration, dark respiration rate and activities of several related enzymes were measured and analyzed. The purpose was to study the influence of N forms on the carbon metabolism in plants. Wheat seedlings grew better in solution supplied with nitrate. The detrimental effect of ammonium on the growth could be reverted partially by increasing the pH of culture medium to 7.0. CO_2 compensation concentration was 15 ppm lower for nitrate-grown plant than for ammoniu-grown plants. However, the difference was also oriented partly by the pH of culture solution. pH value of tissue extracts was not affected by N treatment despite the marked fluctuation of pH in the surrounding nutrient medium. Ammonium-grown plants had higher total titratable acidity but much lower malate content than nitrate-grown plants, suggesting that a considerable amount of CO_2 was fixed in both the leaf and root tissue. This assumption is further supported by the facts that wheat seedlings supplied with ammonium nutrition had higher RuBP carboxylase acitivty in the leaves and PEP carboxylase activity in the roots. Values of the latter (up to 210 μmol/gfw. hr) is at least 2-3 times higher than those normally found in the leaf blades of most C_3 plants. Wheat seedling supplied with ammonium-N had higher NAD-malate dehydrogenase but similar spartate aminotransferase activity when compared with those supplied with nitrate-N. Ammonium nutrition could increase the CO_2 compensation concentration of wheat seedlings with a temperature range of 21 to 35°C and under 2, 21 and 100% oxygen concentrations. Glycolate oxidase activity was slightly higher but dark respiration rate was significantly higher for plants grown in ammonium that in nitrate. The linear relationship between CO_2 compensation concentration and oxygen concentr ation and theextrapolated finite compensation concentration at zero oxygen suggest that in addition to photorespiration, 'dark' respiration also contribute to CO_2 efflux in the light and the increased CO_2 compensation concentration observed in ammonium grown plants.

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Photorespiration, the O_2- and light-dependent release of CO_2 from the leaves, is an enigmatic process which is inseparable from photosynthetic CO_2 fixation, yet performing no generally acknowledged function. Yamada and Ikeda [28] suggested that photorespiration plays a role in dissipating surplus reducing energy which is harmful to the plants under low CO_2 concentration. According to this hypothesis, nitrate and sulfate consume reducing energy in the same manner as CO_2 and hence are able to affect carbon metabolism. It has been reported that both C_3 and C_4 plants fed with ammonium N have higher CO_2 compensation concentration than plants fed with nitrate-N [4,26]. Both glycolate oxidase and RuBP carboxylase/oxygenase activities have been suggested to be related to this phenomenon [9,18] However, 'dark' respiration is also proposed to contribute CO_2 efflux in the light [1].

The sources and availability of N are believed to affect carbon metabolism in the plants [5,10]. Its implication on plant productivity has also been assessed [4]. Many research projects focused on the influences of nitrate and ammonium nutrition on photosynthesis and related reactions have been executed and published in recent years. Photorespiration is usually of major concern because of its relationship with plant productivity. However, factors controlling CO_2 compensation concentration as a result of N influence have not been fully understood. In the present investigation, several variables affecting CO_2 compensation concentration were studied with wheat plants grown in either nitrate or ammonium nutrient solution. The purpose was to further clarify the inter-relationship between the metabolism of N and carbon.

Materials and Methods

Seeds of a spring wheat (*Triticum aestivum* L.) cultivar, Dirkwin, of about the same weight (30—35mg) were soaked in aerated distilled water for 24 hr followed by germinating in petri dish and kept in a growth chamber (Conviron model E-15, Controlled Environments Co.) at day/night (14/10 hr) temperature of 26/18°C under darkness for six days. Uniform seedlings about 8 cm in height were transplanted to plastic pots and grown hydroponically with the basic salts of Hoagland formulation. Four seedling were grown in a pot with 2.5 1 of culture solution. Nutrient solution was aerated vigorously using a small compressor connected via perforated Tygon tubings. Plants were kept in the same growth chamber under a daily regime of 14-hr light at 26°C and 10-hr dark at 18°C. Illumination was provided with fluorescent and tungsten lamps giving 700 $\mu E/m^2 \cdot sec$ of irradiation at the top of the plants.

The culture solution contained the following essential elements with the specified concentrations (mg/l): K^+: 234, Ca^+ : 200, Mg^{2+} : 48, PO_4^{3+} : 95, SO_4^{2-} : 192, BO_3^{3-} : 2.9, Fe (as Fe-EDTA) : 2.2, Mn^{2+} : 0.27, Zn^{2+} : 0.13, Cu^{2+} : 0.13, and MoO_4^{2-} : 0.07. Nitrogen was supplied as either NO_3^--N or NH_4^+-N with a concentration of 100 ppm. The pH of the freshly prepared solution was 4.95-5.00.

In experiments 1 and 3, wheat seedlings were grown in the above solution. pH was determined daily and the solution was renewed in an 48-hr interval. At the 11th day after transplanting, part of the plants was transferred from ammonium to nitrate

medium and part from nitrate to ammonium medium in experiment 1. In experiment 2, pH of the culture solution containing either NO_3^- or NH_4^+ was adjusted daily to 3.0 and 7.0, respectively, and the changes of pH were checked immediately before each pH adjustment. Items of measurement and analysis were shown in the tables and figures of the text.

Carbon dioxide compensation concentration was determined in a closed gas exchange system. Fully-expanded wheat leaf blades were enclosed in a ventilated plexiglass chamber. Illumination was provided by an 800W quartz-tungsten lamp (Sylvania DXW) cooled with an 8-cm layer of running tap water. Temperature inside the chamber ($28\pm0.2°C$) was controlled by circulating water through a jacket and was measured using a copper-constantan thermocouple. The decrease of CO_2 concentration inside the chamber was measured with an Anarad model 500 infrared gas analyzer. The concentration at equilibration was taken as CO_2 compensation concentration. Details of the measurement were illustrated by Clegg *et al.* [2] and Ehleringer and Cook [7].

In most cases, the plexigalss chamber was flushed briefly with CO_2-free air before determining CO_2 compensation concentration. In experiment 3, the chamber was also flushed, individually, with 2, 21 and 100% oxygen (practically CO_2-free). Temperature inside the chamber was also kept at 21 or 35°C in addition to the 38°C mentioned above. The measurements proceeded from low to high temperature and oxygen concentrations.

After measuring CO_2 compensation concentration, dark respiration was measured in the same system. The chamber was darkened with aluminum foil, briefly flushed with CO_2-free air, and the leaves allowed to respire until a constant rate of CO_2 evolution was maintained, which occurred in 6 to 10 min. The leaves was removed and the leaf area determined with a Li-Cor LI-3100 leaf area meter. Dark respiration was calculated as mg $CO_2/dm^2 \cdot hr$ [23].

Activity of RuBP carboxylase (RuBPC) was determined by the method of Lorimer *et al.* [19], PEP carboxylase (PEPC) was after Spalding and Edwards [24], NAD-malate dehydrogenase (MDH) after Edwards and Gutierrez [6], NADP-malate dehydrogenase after Johnson and Hatch [15], aspartate aminotransferase after Hatch and Mau [13], and glycolate oxidase after Fair *et al.* [8]. Malate was determined according to the method of Hatch [12], total titratable acidity by the method of Ku *et al.* [17], soluble protein by Lowry *et al.* [20] and chlorophyll by Wintermans and De Mots [27]. Results shown are the means of two to four replicates.

Results

Vigorous plant growth in the nitrate medium (initial pH 5.0) caused rapid drift towards alkalinity in the culture solution, conversely with the ammonium medium plant growth caused an acid drift. Fig. 1 showed that during a 2-day duration (13th to 15th day after transplanting, switching of solution from nitrate to ammonium or ammonium to nitrate was held at the 11th day), wheat seedlings supplied with nitrate increased pH of the culture medium from 5.0 to 6.5—6.8 and with ammonium from 5.0 to about 3.

The extent of pH drift was correlated with plant age and size. For example, the increase of pH for the nitrate-grown plants between the 15th and 17th days was from 5.0 to as high as 7.4. The drift occurred mainly in the first day after the renewal of culture solution (Fig. 1).

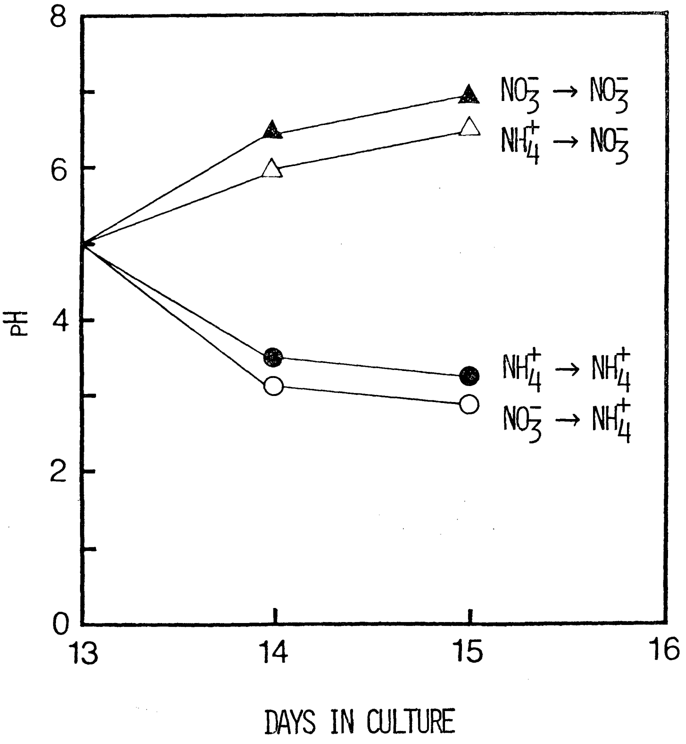

Fig. 1. Changes in pH of culture medium when wheat seedlings wese grown hydroponically with different sources of nitrogen. The initial pH of the culture medium was 5.0. (Exp. 1)

Wheat seedlings grew better in the nitrate than in the ammonium culture solution (Fig. 2, experiment 1). Between the 5th day and 21st day after transplanting, nitrate-fed plants showed a 16-fold increase in fresh weight while ammonium-fed plants had only a 3-fold increase. For the plants transferred from nitrate to ammonium or from ammonium to nitrate at the 11th day, the growth pattern afterwards was similar to those grown continuously in ammonium and nitrate solutions, respectively. In other words, the poor growth caused by ammonium nutrition could be reversed by switching the plants to nitrate-containing solution. Conversely, growth of the nitrate-fed plants was retarded if ammonium was provided as the sole N source. However, older seedlings tended to adapt ammonium-N better than younger ones. Between 11th and 21st days, $NO_3^- \rightarrow NH_4^+$ plants gained 4.5 g fresh weight per seedling but plants grown continuously in ammonium gained only 1.8 g.

pH value of the culture solution also showed significant effect on the growth of wheat seedlings (Fig. 4, experiment 2). Growth was extremely poor in the NO_3-pH 3.0

treatment. The shoots were dark green in color with no visual increase in plant height. The roots became thicker and yellower in color and were curled in order to avoid contacting the injurious acidic solution. Increasing medium pH was beneficial to the growth of plants fed with ammonium. As shown in Fig. 4, NH_4^+-pH 7.0 treatment was better than NH_4^+-pH 3.0 in sustaining plant growth. Similar to the result of experiment 1 (Fig. 2), NO_3^--pH 7.0 was the best among four treatments in terms of gain of plant fresh weight. It is apparent that an interaction between N sources and pH value exists.

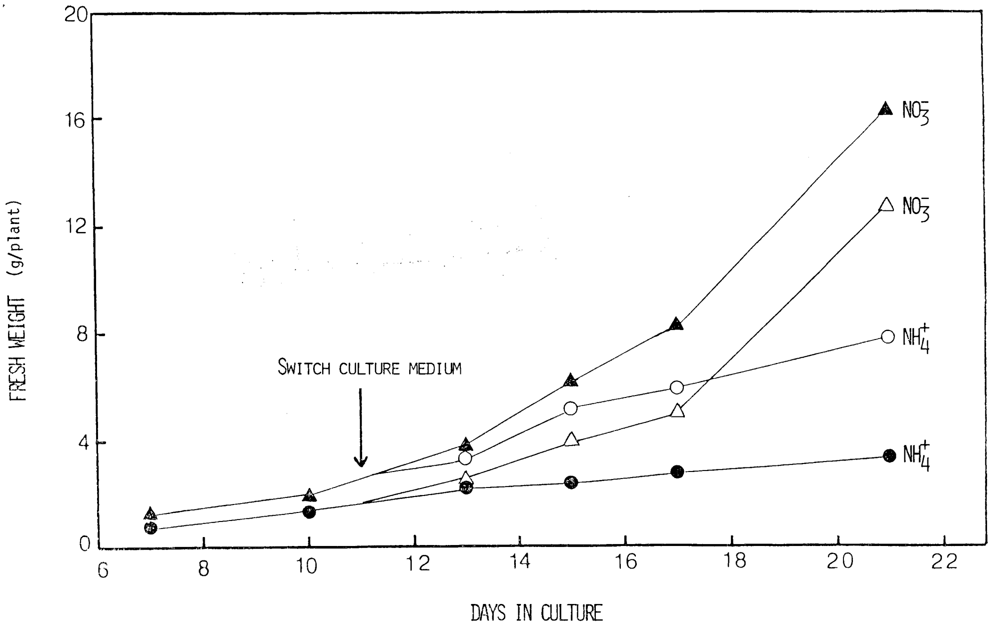

Fig. 2. Influence of nitrogen source on the fresh weight of wheat seedlings. Culture medium was renewed every two days. Switching of culture medium (NO_3^- to NH_4^+ or NH_4^+ to NO_3^-) was performed on the 11th day. (Experiment 1)

Data collected on CO_2 compensation concentrations of leaf blades of nitrate- and ammonium-grown plants were shown in Fig. 3 (experiment 1). The average value of CO_2 compensation concentration was 72 ppm for the ammonium-grown plants and 57 ppm for the nitrate-grown plants. It appears that growth under nitrate may result in CO_2 compensation concentration values about 15 ppm lower than growth under ammonium. No significant fluctuation was observed during the course of the study. When the wheat plants were transferred from a nitrate-N medium to an ammonium-N medium, CO_2 compensation concentration increased from 57 to 69 ppm within one day and decreased gradually thereafter. The value was only 57.5 ppm 9 days after medium switching (Fig. 3). On the other hand, CO_2 compensation concentration decreased sharply immediately after transferring the plants from ammonium to nitrate solution. The decrease, from 72 ppm to 57 ppm, was completed within two days (Fig. 3).

In experiment 2, higher and increasing CO_2 compensation concentration values were

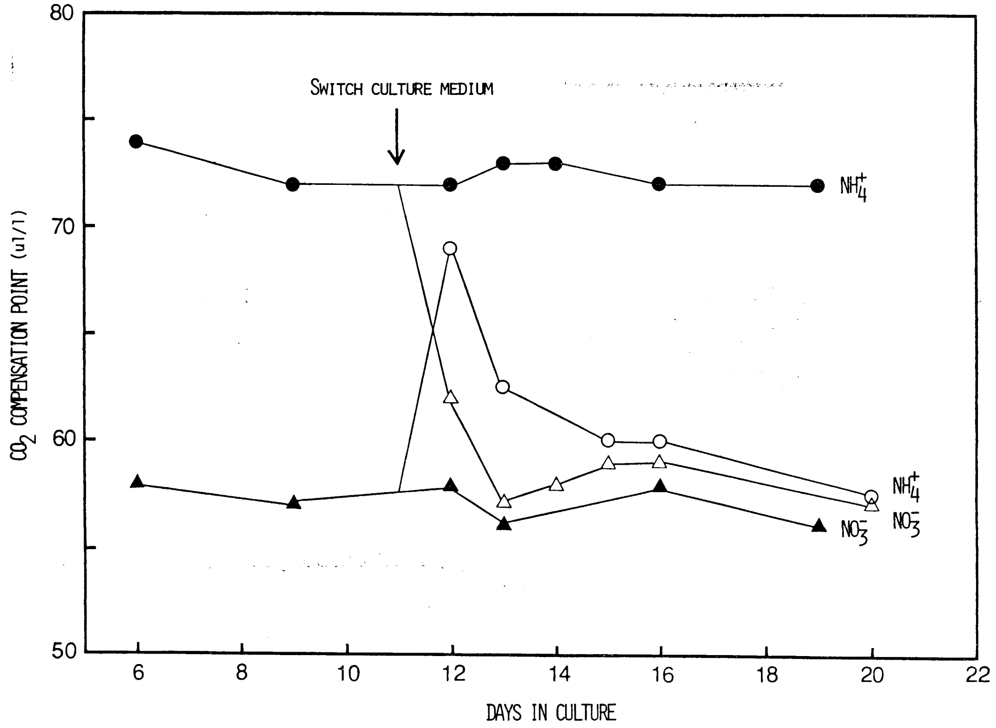

Fig. 3. Effect of nitrogen source on the CO_2 compensation concentration of the leaf blades of wheat seedlings. (Experiment 1)

observed in NH_4^+-pH 3.0 treatment (Fig. 5). The increase was from 70 to 85 ppm during an 8-day duration from 6 to 14 days after transplanting. Compared with the results of Fig. 3, it appears that lowering pH of the ammonium culture medium tended to give higher CO_2 compensation concentration of wheat seedlings. In contrast, high pH (7.0) showed an effect to lower the compensation point (from 73 to 61 ppm) when ammonium N was supplied to the plants. The poorly-grown plants in NO_3^--pH 3.0 treatment also had increased compensation concentration values which were, however, lower than those of the NH_4^+-pH 3.0 plants. The above results show that in addition to N sources, pH of the culture medium has a definite effect on the status of CO_2 equilibration of wheat plant in a closed system.

Although significant changes in pH of different N media were observed as a result of wheat growth, comparisons on pH of tissue extracts among N treatments did not show marked differences (Table 1). pH values of leaf blade extracts were between 5.89 and 5.99 for the 17-day-old seedlings. Extracts of roots grown in nitrate at the time of assay had pH of 6.14—6.33 which were slightly higher than the extracts from ammonium-grown roots (5.75—6.05). Possibly the low pH of ammonium medium had more pronounced influence on the growth of root than on leaf tissue. The total titratable acidity and malate content of leaf blades and roots of experiment 1 are shown in Tables 1 and 2, respectively. In plants supplied with ammonium N at the time of assay there was a significant higher titratable acidity but lower malate content, especially in the leaf tissue.

Table 1. Effects of nitrate and ammonium nutrition on pH and total titratable acidity in the leaf and root extracts of wheat seedlings (Exp. 1)

N Source of Culture Medium[1]	pH		Titratable Acidity[2]	
	Leaf	Root	Leaf	Root
NO_3^-	5.89	6.33	29.3	14.1
$NO_3^- \rightarrow NH_4^+$	5.89	6.05	84.6	26.7
NH_4^+	5.95	5.75	103.0	31.6
$NH_4^+ \rightarrow NO_3$	5.99	6.14	36.3	19.5

[1]17-day-old seedlings were used for assay. Culture media were renewed every 2 days. Switch of medium was performed at the 11th day.
[2]In the unit of μeq/gfw.

Table 2 also showed the results of some biochemical analyses of experiment 1. In the leaf blades of the 21-day-old wheat seedlings, PEP carboxylase (PEPC) activities of various N treatments ranged from 29 to 37 μmol/mg chl • hr which are similar to the activities normally found in C_3 plants. Seedlings grown continuously in nitrate or ammonium medium had relatively higher activities than those transferred to a different medium at the 11th day. In the case of RuBP carboxylase (RuBPC), plants of NH_4^+ and $NH_4^+ \rightarrow NO_3^-$ treatments had significantly higher activities than the plants grown conti-

Table 2. Effect of N nutrition on the activities of various enzymes and soluble protein and malate contents in the leaf and root of wheat seedlings[1] (Exp. 1)

Measurement	NO_3^-	$NO_3^- \rightarrow NH_4^+$	NH_4^+	$NH_4^+ \rightarrow NO_3^-$
Leaf				
PEP carboxylase (μmol/mg chl • hr)	34.4	28.9	36.5	29.0
RuBP carboxylase (μmol/mg chl • hr)	873	863	1,115	1,059
Aspartate aminotransferase (μmol/mg chl • hr)	94	99	126	96
NADP-malate dehydrogenase (μmol/mg chl • hr)	48	40	56	48
NAD-malate dehydrogenase (μmol/mg chl • hr)	6,400	6,110	8,810	7,640
Soluble protein (mg/gfw)	38.5	36.9	39.5	40.2
Malate (μeq/gfw)	4.43	0.09	0.32	1.22
Root				
PEP carboxylase (μmol/gfw • hr)	48	141	210	47
Soluble protein (mg/gfw)	9.9	13.8	15.5	10.2
Malate (μeq/gfw)	3.60	0.15	0.94	2.30

[1]21-day-old seedlings were used for assay of RuBPC, aspartate aminotransferase and NADP- and NAD-MDH. All other measurements were made on 17-day-old seedlings. Swtch of culture medium was performed at thie 11-th day.

nuously or originally in NO_3^- medium (1,059-1,115 vs. 863-878 μmol/mg chl • hr).

NAD-MDH is the principal enzyme responsible for the conversion of oxalacetate to malate in wheat while NADP-MDH is of negligible importance (Table 2). Wheat seedlings grown continuously or originally in ammonium medium had significantly higher NAD-MDH activities, similar to the results obtained on RuBPC. Activity of aspartate aminotransferase, which catalyzes the conversion of oxalactate to aspartate, were at least 60 times lower than those of NAD-malate DH (Table 2). These results suggest the preference of wheat seedlings in utilizing oxalacetate during photosynthesis. Aspartate aminotransferase activity was higher for plants continuously fed with ammonium than for plants in the other three treatments.

The high PEPC activity, up to 210 μmol/gfw • hr, found in the roots of ammonium-grown plants was at least 2—3 times higher than those exhibited by leaf blades when the same unit is used for comparison (84.0 and 60.1 μmol/gfw • hr for NH_4 and No_3^- $\rightarrow NH_4^+$ treatments, respectively). The high PEPC activities were associated with high soluble protein contents in the roots (Table 2).

Table 3 indicated that maintaining the pH of nitrate or ammonium medium at 3.0 or 7.0 did not affect consistently PEPC activity in the leaf blades. In spite of the higher activities of RuBPC and glycolate oxidase in ammonium than in nitrate treatment, changes in pH did not show significant effect on the activities of the two enzymes within individual N source treatment. Similar to the results shown in Table 2, ammonium-grown plants had very high PEPC activity in the roots. Increasing pH from 3.0 to 7.0 in ammonium medium was able to enhance malate content in both leaf blades and roots and decreasing pH from 7.0 to 3.0 in nitrate medium gave higher malate content in the leaf blades. One remarkable fact is that the poorly-developed roots in NO_3^--pH

Table 3. Effect of N form and pH of the culture medium on the activities of various enzymes and soluble protein and malate contents in the leaf and root of wheat[1] (Exp. 2)

Measurement	NO_3^-		NH_4^+	
	pH 7.0	pH 3.0	pH 7.0	pH 3.0
Leaf				
PEP carboxylase (μmol/mg chl • hr)	36.0	33.7	34.8	35.8
Glycolate oxidase (μmol/mg chl • hr)	121	107	136	133
RuBP carboxylase (μmol/mg chl • hr)	616	713	846	853
Soluble protein (mg/gfw)	36.8	41.8	33.7	40.5
Malate (μeq/gfw)	7.70	9.40	0.32	1.99
Root				
PEP carboxylase (μmol/mg chl • hr)	63.5	49.6	149.2	136.0
Soluble protein (mg/gfw)	9.5	31.8	12.1	11.8
Malat (μeq/gfw)	3.77	2.64	0.63	1.64

[1]13-day-old seedlings were used for all analyses.

3.0 treatment contained soluble protein almost 3 times higher tahn those in the other treatment (Table 3). Actually soluble protein content as high as 60 mg/gfw was recorded in the rootsof this treatment prior to 10 days after transplanting (data not shown).

The response of CO_2 compensation concentration to oxygen concentration was determined to study the contribution of photorespiration to the increased compensation concentration caused by ammonium nutrition. Fig. 6 showed that at any given oxygen concentration or temperature, leaf blades had a higher CO_2 compensation concentration when plants were grown in ammonium than in nitrate medium. The difference increased with increasing temperature or oxygen concentration. CO_2 compensation concentration increased linearly with oxygen concentration from 2 to 21 to 100% at each temperature studied which indicated possible contribution of 'dark' respiration to CO_2 efflux by either photosynthesizing or non-photosynthesizing cells, or both.

The leaf blade dark respiration rates of plants supplied with different N sources in relation to oxygen concentration were then determined and the results are shown in Fig. 7. It is obvious that dark respiration rates were higher for ammonium-grown plants than for nitrate-grown plants at each oxygen concentration studied. There was a marked increase in dark respiration when oxygen concentration increased from 2% to 21%. The increase from 21% to 100% oxygen was less significant. The non-linearity between dark respiration and oxygen concentration was not parallel to the relationship between CO_2 compensation concentration and oxygen concentration as shown in Fig. 6.

Discussion

The culture medium containing anionic nitrate became more alkaline and those with cationic ammonium more acidic with the advance of wheat growth (Fig. 1). The changes in external pH are due to excretion of hydrogen ions by the plants upon ammonium uptake, and hydroxyl ions upon nitrate uptake[25]. The lower pH exhibited by switching plants from nitrate to ammonium than by growing continuously in ammonium is probably the result of larger root volume and hence higher absorption capability of the former.

Weight gains by adding ammonium to an all nitrate system have been observed in many plant species[14]. Cox and Reisenauer[3] reported that the growth rate and yield of wheat were enhanced under similar condition. The enhancement was suggested to result from the reduced energy requirement in using ammonium in protein synthesis. However, ammonium alone usually possesses a detrimental effect on plant growth. Results of this experiment showed that the growth of wheat seedlings was inferior when grown under ammonium nutrition (Fig. 2). Possible causes are the toxicity of ammonium ion to plant metabolism and the lowering of pH in culture medium. Fig. 4 indicated that the growth of wheat seedlings was increased when the pH of the ammonium-containing medium was adjusted daily to 7.0.

Despite the significant changes of pH in culture media, the pH values of tissue ex-

tracts of leaf blades and roots showed insignificant difference among N treatments (Table 1). Only the roots of wheat seedlings grown continuously in ammonium showed a lower pH of 5.75. In general, when ammonium ion is assimilated into organic-N in the roots, the excess hydrogen ions generated are excreted to the surrounding solution. On the other hand, hydroxyl ions produced in the cell cytoplasm when plants are grown in nitrate are partly exceted from the roots and partly neutralized by the production of organic acids[22]. Furthermore, ionic balance within the plant is achieved by the action of organic acid anions such as malate and citrate[14].

Total titratable acidity in the leaf blades and roots were higher in the ammonium than in the nitrate treatment which were in accordance with the pH values of plant tissue (Table 1). However, the differences in titratable acidity were not in agreement with those in malate concentration (Table 2). These results suggest that a considerable a mount of CO_2 was fixed (acidification) by the ammonium-plants[17]. Further evidences were that wheat seedlings supplied with ammonium nutrition had higher RuBPC activity in the leaves and PEPC activity in the roots than plants supplied with nitrate nutrition (Table 2).

De Benedetti *et al.*[5] reported that ammonium-grown chloroplasts had higher RuBPC activity resulted from the activation of the enzymatic reaction by ammonium ion, or the faster utilization of RuBP in the presence of ammonium. Golvano *et al.*[10] suggested that ammonium nutrition seemed to stimulate the enzyme activity in parallel to the stimulation of protein synthesis. Table 2 showed that soluble protein concentration was relatively the same between N treatments for the 21-day-old seedlings. It is probable that higher RuBPC activity of ammonium-grown plants is the result of higher activity rather than amount of RuBPC protein.

Nitrogen sources showed little influence, if any, on the PEPC activity of leaf blades (Table 2). In nitrate-grown plants, the ratio of activities of RuBPC/PEPC was lower than in ammonium-grown plants. similar result has been reported by Winter *et al.*[26] on *Moricandia arvensis*, a C_3-C_4 intermediate. Little information is available on the influence of N forms on PEPC activity in the roots. This investigation revealed that ammonium had a consistent and significant effect in stimulating PEPC activity in the wheat roots (Tables 2 and 3, and unpresented data). The higher activity was accom panied by a higher content of soluble protein (Table 2). The extraordinarily high activity is not commonly found in the root tissue of C_3 plant. Its implication, in addition to the acidification reaction proposed earlier, has yet to be determined.

Oxalacetate formed in the cells can be reduced to malate catalyzed by NAD-MDH or converted to aspartate by aspartate aminotransferase. Wheat seedlings possessed high activity of NAD-MDH (up to 8,800 μmol/mg chl • hr, see Table 2) which was at least 5 times higher than the combined activity of NAD- and NADP-MDH in a succulent C_4 dicot, *Portulaca grandiflora*, reported by Ku *et al.*[17]. On the contrary, a spartate aminotransferase activity was low in the tested plants(ca. 100 μmol/mg chl • hr). Generally, activities of both enzymes were higher in plants supplied with ammonium than with nitrate medium. This is not in agreement with the result of malate content (Table 2).

The role of NAD-malate DH in wheat seedlings grown with ammonium N remained to be clarified.

Irrespective of N sources, pH value of the culture medium could affect some physiological characteristics of the hydroponically cultured wheat. Growth of wheat seedlings was extremely poor in nitrate medium with pH value adjusted daily to 3.0. On the other hand, ammonium medium at pH 7.0 was beneficial to the plants compared with ammonium-pH 3.0 treatment (Fig. 4). The experimental results on tomato of Tiedjens and Robins, as reported by Street and Sheat [25], showed that although ammonium was absorbed at pH 4.0 it was not assimilated and had a toxic effect; at pH 7.0-8.0 ammonium was effectively assimilated and supported a high level of growth. The low pH (3.0) used in this experiment is considered injuriously acidic to root growth. A significant amount of undissociated nitric acid might be present and hence inhibit the development of root system [25]. A very high soluble protein content (31.8 mg/gfw) was observed in the roots, but not leaves, of wheat seedlings grown in nitrate at pH 3.0 (Table 3). Possibly soluble protein could counteract the toxic influence caused by the low pH value through some unexplained mechanisms.

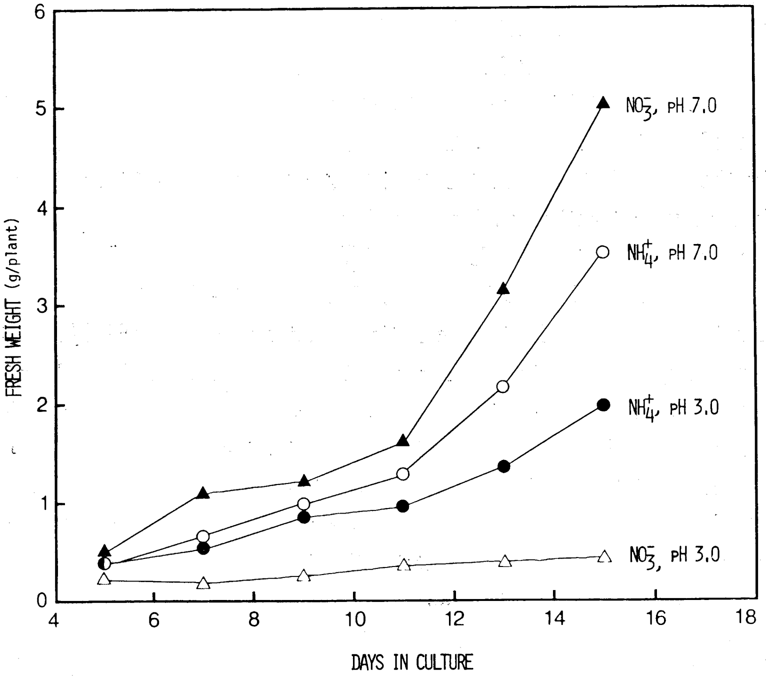

Fig. 4. Influence of nitrogen source and pH of culture medium on the fresh weight of wheat seedlings. Nutrient solution was renewed every 2 days and pH adjused daily. (Experiment 2)

The high CO_2 compensation concentration associated with ammonium nutrition (Fig. 3) has been reported on a variety of plant species. Cresswell [4] found both C_3 and C_4 plants to exhibit a lower CO_2 compensation concentration with nitrate than with ammonium as the N source. Fig. 3 of this study also found the CO_2 compensation con-

centration of wheat seedlings was 15 ppm lower with nitrate than with ammonium as the N source. However, such a difference seemed to be pH-oriented as there was a marked decrease in compensation concentration when wheat seedlings were grown in ammonium medium maintained at pH 7.0 (Fig. 5). Photorespiration has been considered to play a role in dissipating surplus reducing energy which might be toxic to photosynthetic tissue. Yamada and Ikeda[28] proposed that materials which consume reducing energy, such as nitrate and sulfate, regulate photorespiration and thus plants with nitrate as the sole N source tend to have a lower CO_2 compensation concentration.

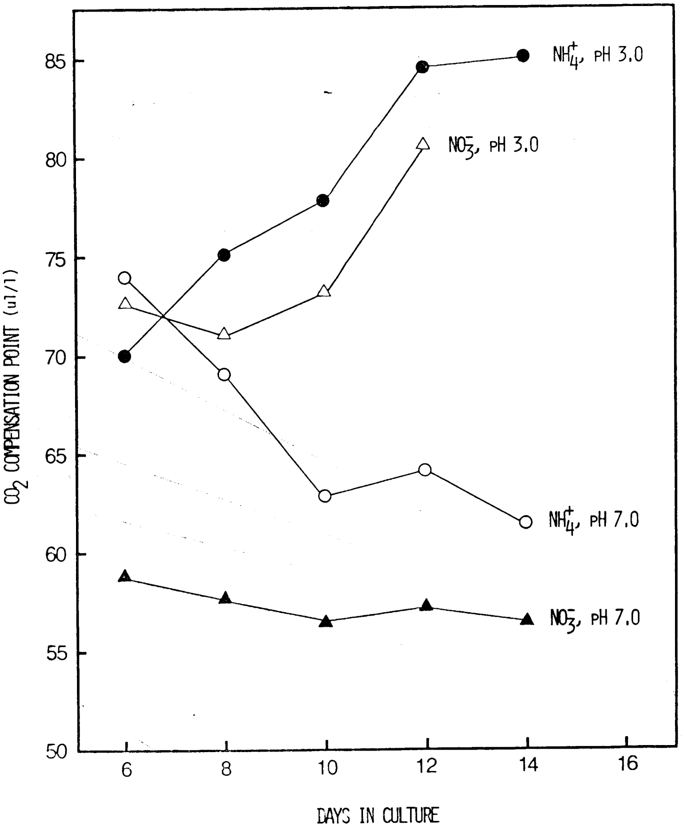

Fig. 5. Effect of nitrogen source and pH of culture medium on the CO_2 compensation point of wheat seedlings. (Experiment 2)

The mechanism of how N nutrition affects photorespiration has not been fully understood. Fair *et al.*[9] reported that the increase in glycolate oxidase activity in the ammonium-grown plants was greater than the corresponding increase in RuBPC activity and the difference was reflected to the higher CO_2 compensation concentration. From Table 3 of this experiment, glycolate oxidase activity was slightly higher for ammonium- than for nitrate-grown plants. However, such difference is not in accordance with the trends of changing CO_2 compensation concentrations as shown in Fig. 5. Kestler *et al.*[16] suggested that the ratio of RuBP oxygenase (RuBPO)/RuBPC determined the photosynthetic CO_2 compensation concentration in leaves of higher phlants. Nitrogen

nutrition did not show any effect on the PEPC activity (Tables 2 and 3). While RuBPC activity increased in ammonium-grown plants, RuBPO activity was not verified in this experiment or in other related reports. Winter *et al* [26], in studying *Moricandia arvensis*, found 2-fold higher PEPC activity and low ratio of activities of RuBPC/PEPC in the nitrate-grown than ammonium-grown plants. They concluded that PEPC may have a relatively greater role in carbon assimilation in plants supplied with nitrate. Although the present study obtained similar results on the ratio of activities of RuBPC/PEPC in response to N nutrition, the difference in ratios was caused completely by RuBPC because both nitrate and ammonium treatment failed to show any significant difference in PEPC activity (Table 2). In other words, enzymatic reactions controlling photosynthetic CO_2 compensation concentration in relation to N status need to be studied in the future.

In an attempt to elucidate whether the increase in CO_2 compensation concentration caused by ammonium is due to an increase in the photorespiratory rate, the influence

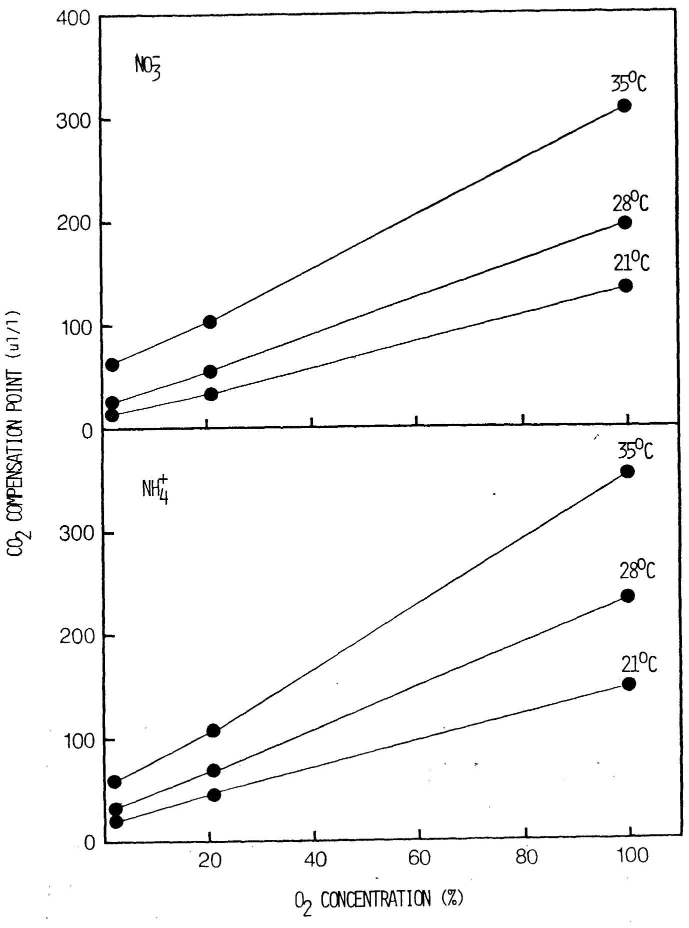

Fig. 6. Influence of temperature and O_2 concentration on the CO_2 compensation point of wheat seedlings supplied with different forms of nitrogen. 14-day-old seedlings were used. (Experiment 3)

of different oxygen contrations on CO_2 compensation concentration was studied in this experiment. The positive and linear relationship between the two characters (Fig. 6) strongly suggests that the increased CO_2 compensation concentration exhibited by the wheat seedlings grown in ammonium N nutrient medium is due to an increase in the output of CO_2 by the plant rather than to a decrease in the uptake of CO_2. Grossman and Cresswell[11] found that sugarcane and corn plants receiving ammonium N responded to oxygen in a similar manner to that usually found in C_3 plants. The linear increase of the compensation concentration with oxygen concentration can be explained by considering only the kinetic of the enzyme RuBPC/RuBPO. However, the observed positive value of CO_2 compensation concentration when oxygen concentration is extrapolated to zero (Fig. 6) suggest the possibility of the occurrence of some 'dark' respiration in photosynthesizing cells under illumination (or day respiration), although other cells may also contribute to CO_2 efflux[1]. The tricarboxylic acid cycle is likely to be the most important contributor to dark respiration and it occure in the light[21]. Results of Fig. 7 showed dark respiration rate was significantly higher for plants grown in ammonium than in nitrate medium under three different oxygen concentrations, which can be used as an indirect evidence to show the possible contration of dark respiration to the high compensation concentration of ammonium-grown plants. .

Carbon dioxide compensation concentration generally increase with increasing temperature (Fig. 6). Laing et al. [18] explained this phenomenon in terms of the kinetic properties RuBPC/RuBPO, i. e., by the temperature dependence of compensation concentration in the absence of any other process. Azcon-Bieto *et al.* [1], on the contrary, showed that simulation of these effects appeared insufficient to account for rapid increase of CO_2 compensation concentration at high temperature and concluded that inclusion of 'dark' respiration yielded more realistic predictions. Parallel relationship between

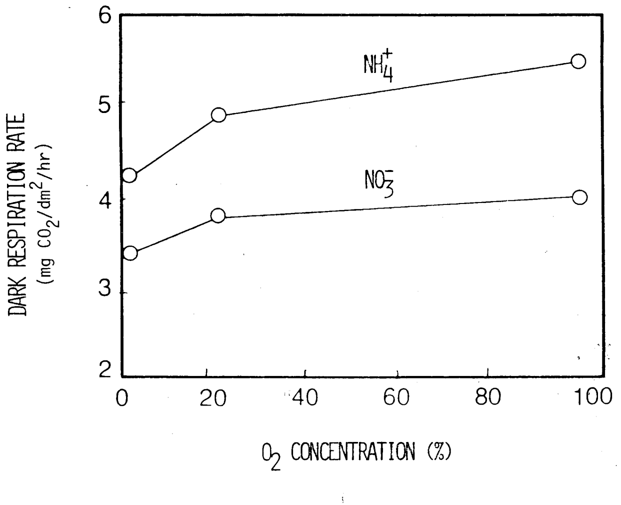

Fig. 7. Influence of O_2 concentration on the rate of dark respiration of wheat seedlings supplied with different forms of nitrogen. Results of 5 measurements on 11-to 21-day-old seedlings were averaged and presented. (Experiment 3)

CO_2 compensation concentration and dark respiration rate at 28 and 35°C under different oxygen concentrations (data not shown) seems in favor of the hypothesis made by Azcon-Bieto *et al.* [1]. However, the non-linear response of dark respiration rate to oxygen concentrations (Fig. 7) suggested that although dark respiration might be involved in CO_2 efflux in the light, increased photorespiratory rate is still of importance in contributing the high CO_2 compensation concentration caused by ammonium nutrition.

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硝酸態與銨態氮源對小麥生長、光呼吸、暗呼吸及相關酵素活性的影響[1]

劉 大 江[2]

摘 要

本試驗以小麥幼苗爲材料，以 100 ppm 之硝酸態或銨態氮爲氮源，測定小麥生長、二氧化碳補償濃度、暗呼吸速率及一些酵素活性的變化，目的在瞭解氮素代謝對碳素代謝作用的影響。小麥在含硝酸態氮源的水耕液內生長較佳，唯銨態氮源對生長的不利作用可經由維持水耕液 pH 值於 7.0 而獲得部分改善。小麥生長於銨態氮源下的二氧化碳補償濃度較生長於硝酸態氮源下高 15 ppm 左右，但此項差異亦可經由提高水耕液 pH 值而減小。雖然小麥生長於不同氮源可導致水耕液 pH 值的明顯變化，植株萃取液的 pH 值却大致相近。銨態氮源條件下生長的小麥含有極高的可滴定酸度 (total titratable acidity) 和極低的 malate 含量，顯示必需固定較多的二氧化碳以維持植株內的離子平衡 (ionic balance)，此項假設可由葉片內較高的 RuBP carboxylase 活性與根部較高的 PEP carboxylase 活性得到證明，後一酵素於根部的活性可高達 210 μmol/gfw • hr，爲多數 C_3 型植物葉片同一酵素活性的二至三倍。銨態氮源下生長的小麥同時含有較高的 NAD-malate dehydrogenase 活性，但 aspartate aminotransferase 活性則與硝酸態氮源處理者相近。在 21-35°C 的溫度與 2-100%氧氣濃度下，銨態氮源處理植株的二氧化碳補償濃度均顯著高於硝酸態氮處理的結果；前者的 glycolate oxidase 活性略高，但暗呼吸速率却顯著高於後者。二氧化碳補償濃度與氧氣濃度間有直線關係，但 0 %氧氣濃度下的二氧化碳補償濃度仍爲正值，表示除了光呼吸作用外，暗呼吸與光照情況下的二氧化碳釋放與銨態氮營養導致之高二氧化碳補償濃度有關。

1.臺灣省農業試驗所 研究報告第 1483 號。

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甘藍低活力種子之探討[1]

劉政道　華愛瑪　柯俐荷　卡　森[2]

摘要　商業用甘藍品種奧斯卡(Oscar)之種子（*Brassica oleracea* L. *Capitata* group）經1－6年諸存後，於 20～30°C 變溫之標準發芽試驗下顯示幾乎可以全部發芽。調控劣變試驗時，將種子之含水量提升至24%，並於 45°C 處理24小時，結果顯示各批種子之活力有極顯著之差異。種子之發芽與萌芽無論在控制環境之實驗室，人工氣候室與田間試驗均顯示其發芽或萌芽速率之減緩、幼苗鮮重之減少以及異常幼苗數目之增加與種子之低活力有顯著之關係。低活力爲導致田間萌芽不良的主要原因之一。

種子爲大多數作物生產之起始點，甘藍亦不例外。種子品質優劣是決定作物生產成功與否的最主要因子之一，傳統上優良品質種子之標準必須具備純潔度高，不含雜草種子，發芽率高，健康以及高種子活力等先決條件，這些種子無論在有設施保護之溫網室或田間均能表現幼苗萌芽整齊及獲致作物最高產量之特性。許多試驗研究已指出作物種子之發芽、田間萌芽及成株等受到種子品質與種子活力之影響很大。使用優良品質與高活力種子通常可預期獲致高的發芽百分率、成株與產量 (3,4,9,10,11,12,13,14,15,18) 。

採收前與採收後之種子老化爲導致商業用種子低活力的主要原因爲一般人所公認 (1,2,7) 。所有器官之老化係指導致器官最後死亡的整個劣變過程之總和，種子被認爲死亡乃種子在沒有休眠並且在最適當之發芽環境條件下失去發芽能力而言。通常種子在失去發芽能力前之整個老化過程中有幾個先驅徵兆會出現 (5,17) ，其中最明顯者爲老化種子之發芽速率降低 ， 其次是種子族羣中產生小苗及不正常苗之比例增加 (8) ， 另外， 類似大粒種子如豆類與玉米等之種子於浸水後其內容物如糖與鉀等物質之保存能力降低等均爲種子老化之明顯徵狀 (16) ，因此，種子老化係一系列導致失去種子活力之衰退過程。

本文係以五批不同年齡與活力之甘藍種子進行探討低活力種子之特性。種子之發芽測定係在標準環境條件下進行，並利用加速老化處理（調控劣變處理）種子進行比較，幼苗萌芽測定係在人工氣候室與田間進行，除了調查發芽及萌芽百分率外，在各試驗中亦進行考量幼苗之品質；而種子發芽溫度範圍之測定則在溫度梯度板發芽器中進行。

材料與方法

一、種子材料

本研究係利用 Royal Sluis 種子公司所提供五批來自三種不同採收年期之商業用雜交一代甘藍品種奧斯卡（Oscar） 種子爲材料，其中二批種子係於1984年採收之新鮮種子，另三批自然老化之種子係各採自於1979與1980年，這五批種子之千粒重如表一所示。各批種子於採收後均在 20°C 及 40%相

1.臺灣省農業試驗所　研究報告第 1484 號，本文爲第一作者博士論文之一部份。
2.本所鳳山熱帶園藝試驗分所副研究員兼經營利用系主任；依次爲荷蘭農業大學園藝系講師，國家種子試驗所研究員，農業大學植物生理系教授。臺灣省　高雄縣　鳳山市。

表1. 不同採收年期甘藍種子千粒重

Table 1. The 1000 seed weight of cabbage seeds harvested in different years.

Year of harvest	1000-seed weight, g
1984—1	5.37
1984—2	3.51
1980	3.11
1979—1	3.15
1979—2	2.94

$LSD_{0.05}=0.70$

對濕度之商業用儲藏條件下保存，至1984年 9 月再移存於 5°C及30%相對濕度之冷藏庫中以減緩種子繼續老化直至使用。本系列試驗在1984與1985年進行。

二、標準發芽試驗

標準發芽試驗係判別各類種子發芽能力之最基本方法，甘藍種子之標準發芽試驗係利用紙質發芽床之方法(Top of paper method)於荷蘭國家種子試驗所之傑考森發芽箱 (Jacobsen germinator) 進行，溫度採用變溫方式即於 20°C暗期 16小時，30°C光期 8 小時，發芽進行中記錄發芽百分率，並依國際種子檢查規則之標準於幼苗發芽後 7 —10天評估幼苗之發育並將幼苗分為正常苗與異常苗。

三、溫度梯度板發芽器試驗

本試驗係利用溫度梯度板發芽器上之不同溫度範圍進行測定甘藍種子之發芽情形，並求其發芽特性曲線，試驗係在荷蘭農業大學植物生理系進行，溫度梯度板發芽器 (Thermogradient plate) 為發芽床，溫度差異範圍為10—34°C，試驗採逢機完全區集設計三重複，相鄰的兩行之間溫度相差3°C，種子播於紙質發芽床上並覆蓋鐘形罩 (bell jar) 於開始發芽後之頭 7 天，每天算計發芽之種子數二次，以後則每天一次，至發芽後之第21天截止。

四、調控劣變試驗

各批甘藍種子之活力差異係利用調控劣變 (controlled deterioration test) 試驗[6]測定之，試驗係在荷蘭國家種子試驗所進行，種子含水量係以低恒溫烘箱法測定之 103±2°C，17± 1 小時)，測定種子含水量時，每次使用 5 公克種子為樣品，共三重複。另將其它20公克種子置於容器中適度加水將種子之含水量調升至預定之24%，調升後將種子置於 20°C 之旋轉盤上至少滾動 2 小時，並儲藏於 10°C 二天以使種子含水量達到平衡，處理結束後再重行測定種子之含水量是否為24%，種子含水量之差異不超過 0.5 %，為使調控劣變試驗達到適度，含水量達到平衡後，一半之種子以鋁箔密封並置於 45°C 之溫水處理24小時，另一半則於 5°C 之恒溫箱過夜，處理後這兩種不同處理之種子於實驗室內進行標準發芽試驗。

五、人工氣候室試驗

甘藍種子之萌芽以及幼苗之活力測定於荷蘭農業大學園藝系之人工氣候室內進行，其間分別於 9、13、17、21及 25°C 中測定，試驗採裂區設計，四重複，每處理播種子50粒於底層含有泥炭土上覆三公分河沙之容器中，播種後另覆 0.4 公分河沙，萌芽期間土壤保持適當濕度，幼苗生長期間，光源為高壓鈉燈及水銀燈強度約35Wm^{-2}，每日光照 8 小時，當幼苗之子葉呈水平展開時即算為萌芽，並於達到一半最高萌芽率後之第19天採收調查幼苗，並將其分級為強壯苗 (>0.5g)，中苗 (0.25—0.5g) 及弱苗 (<0.25g)

六、田間試驗

田間試驗係於荷蘭農業大學園藝系之試驗農場進行，五批甘藍種子分別於1985年6月7日，7月11日，8月16日以及9月25日分四次播種，試驗採逢機完全區集設計四重複，小區播種200粒種子，當幼苗之子葉伸出土壤表面時，算爲萌芽，幼苗萌芽百分率於試驗進行中記錄之，幼苗之生長與發育則於達一半最高萌芽百分率後之第19天進行評估，其分級標準與人工氣候室之試驗相同。

結　果

一、標準發芽試驗

標準發芽試驗結果顯示全部五批種子之發芽百分率均高達90%以上（圖1）然而老化種子之發芽速率表現遲緩且正常苗之百分率亦因老化而顯著降低，如1979年生產之種子所獲之正常苗數僅49%左右。

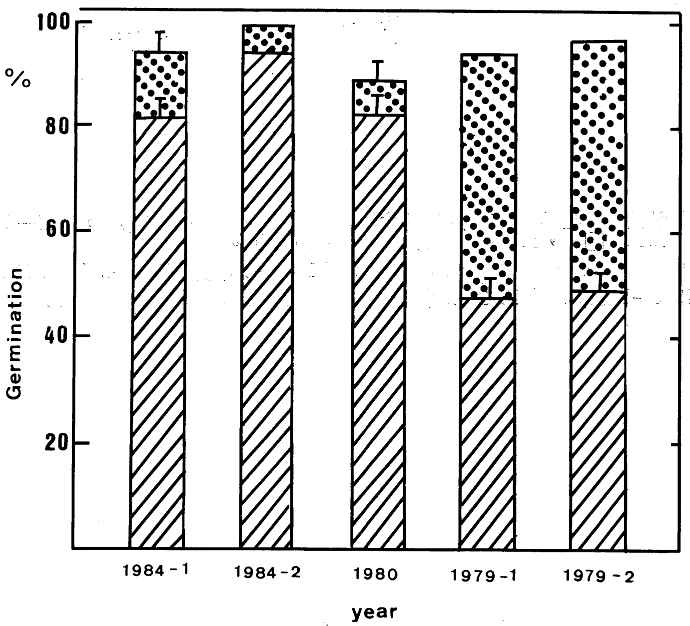

圖1. 五批甘藍種子在 20／30°C 變溫標準發芽試驗之發芽百分率，幼苗分類爲正常（/////）或異常（·:·:·）苗。

Fig. 1. Percentages germination (upper line of bars) of seeds of 5 lots in the standard laboratory germination test at alternating temperatures 20°C—30°C. Seedlings were classified as normal (/////) or abnormal (·:·:·). Single vertical bars indicate standard deviations>3%.

二、溫度梯度板發芽器試驗

溫度梯度板發芽器試驗結果顯示無論新鮮或老化之種子在 16—31°C 之間其最後發芽百分率均在80—95%之間（圖2）如溫度低於 16°C時，1984 年生產之種子發芽百分率減低之幅度較1979年之老化種子緩慢。

發芽速率是以達一半最高發芽百分率之時間倒數値來計算以便區別各批種子之優劣，結果發現1979年之種子發芽速率比新鮮種子緩慢，而1980年之種子則居於1979與1984種子之間（圖3）。

三、調控劣變試驗

調控劣變試驗結果顯示未經處理直接進行發芽之種子與種子含水量調升至 24%儲存5°C之種子其

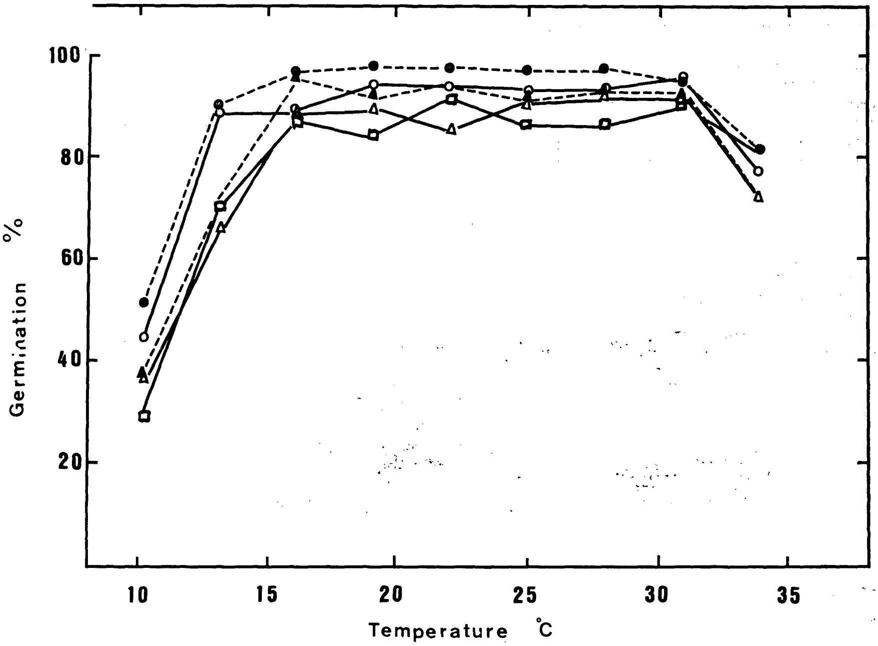

圖2. 五批甘藍種子在10到35°C溫度範圍之發芽百分率，1984—1 (○) ，1984—2 (●) ，1980 (□) ，1979—1 (△) 及1979—2 (▲) 。

Fig. 2. Percentages germination of seeds of 1984—1 (○), 1984—2 (●), 1980 (□), 1979—1(△) and 1972—2 (▲) at temperatures ranging from 10° to 35°C.

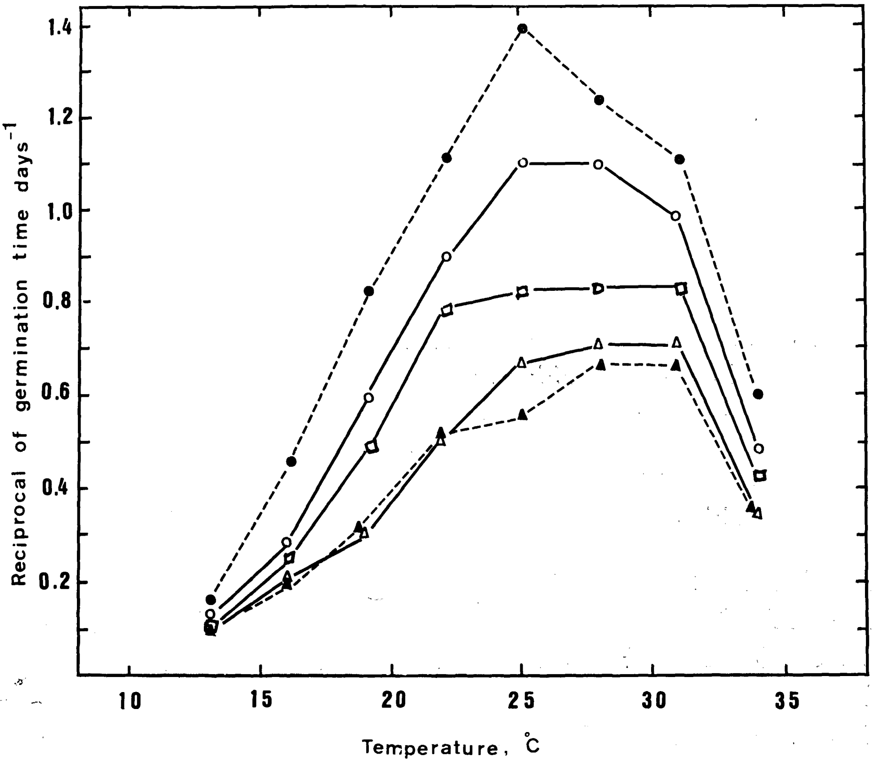

圖3. 溫度與五批甘藍種子達一半最大發芽百分率所需時間倒數值之關係，1984—1 (○) ，1984—2 (●) ，1980 (□) ，1979—1 (△) 及1979—2 (▲) 。

Fig. 3. The relation between the reciprocal value of the time for half-maximal germination and temperature for each lot 1984—1 (○), 1984—2 (●), 1980 (□), 1979—1 (△) and 1979—2 (▲).

發芽率均沒有差異（圖４），然而調控劣變處理（45°C，24 小時）則很顯著的影響種子發芽，在各批種子間有很明顯之差別，只有1984年生產的種子仍保持高發芽百分率且產生相當數目之正常苗。

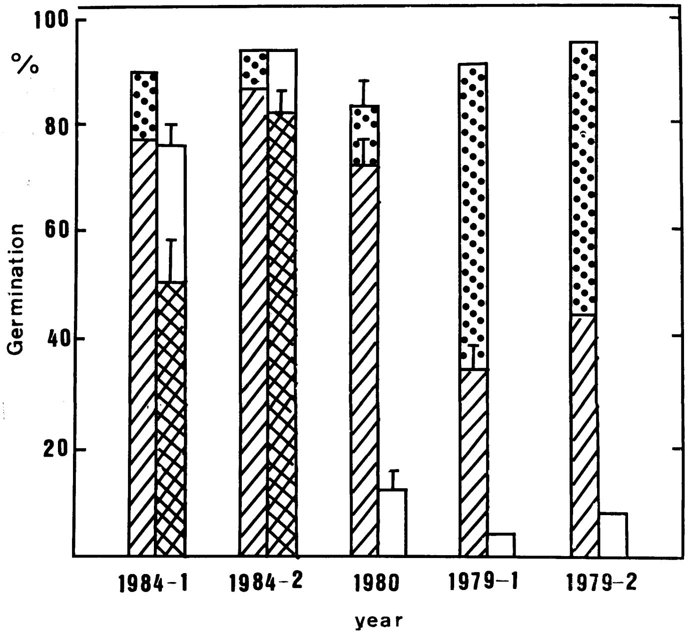

圖4. 五批甘藍種子在標準發芽試驗之發芽百分率，種子含水量調升到24%並貯存於5°C（左柱）或45°C（右柱）24 小時，幼苗分類爲正常（////,XX）或異常（·:·:·，□）苗。

Fig. 4. Percentages germination (upper line of brars) of seeds of 5 lots at the standard laboatory germination test. Moisture content of the seeds was equilibrated at 24% on fresh weight basis. Seeds were stored for 24 hours at either 5°C (left bar of each lot)or 45°C (right bar). Seedlings were classified as normal (////,XX) or abnormal (·:·:·, □). Single vertical bars indicate standard deviations>3%.

四、人工氣候室試驗

溫度對幼苗之萌芽與生長亦在控制環境下之人工氣候室測定，試驗結果發現各批甘藍種子之萌芽百分率在9—25°C之範圍內均達 80%以上，但是達到一半最高幼苗萌芽百分率之時間倒數值於各批種子間有顯著的差異，老化種子萌芽速率顯著的比年輕種子緩慢很多（圖５），各批種子於不同溫度萌芽後之幼苗生育情形於達一半最高萌芽百分率後之第19天進行調查，結果發現僅來自1984年與1980年種子在溫度17—25°C之範圍內所產生幼苗之鮮重每株可達0.25公克以上（圖６）。

五、田間試驗

五批不同甘藍種子，在田間四次不同播種時期之平均萌芽百分率爲13—62%（圖７），７月份播種幼苗萌芽百分率降低，乃因氣候乾燥，噴水後表土形成硬殼影響萌芽所致，1984年種子在各種播種期中萌芽百分率較高，1980以及1979年之老化種子萌芽百分率低。

五批種子間，幼苗之發育與鮮重於達一半最高萌芽百分率後之第19天亦顯示各批種子間與不同播種時期均有很大之變異（圖８）。五批種子在四次不同播種期，其平均幼苗鮮重在0.09—1.60公克之間，1984種子比老化種子產生較多且强壯之幼苗，然在９月過後，各批種子均產生小苗。

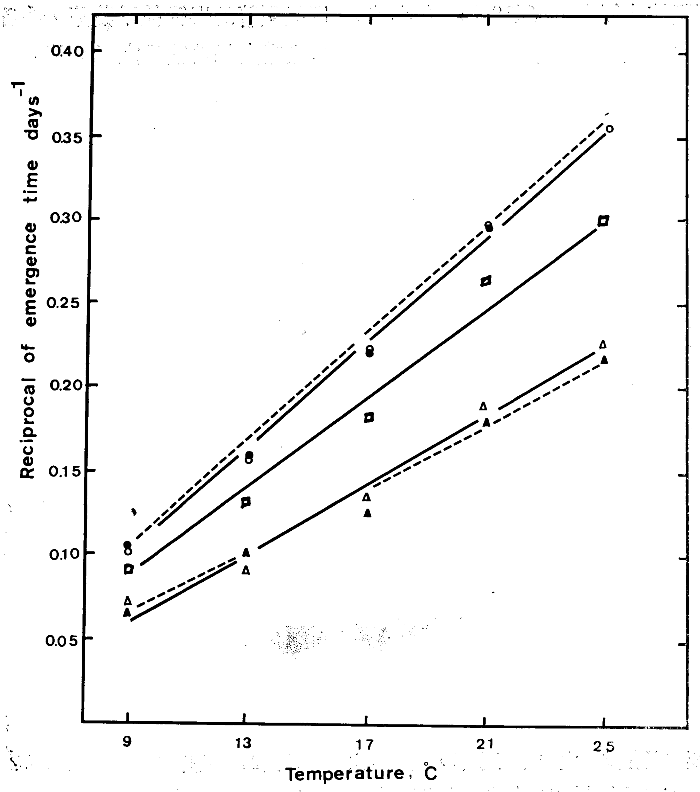

圖5. 溫度與五批甘藍種子在人工氣候室達一半最大萌芽百分率所需時間倒數值之關係，1984—1 (○)，1984—2 (●)，1980 (□)，1979—1 (△) 及1979—2 (▲)。

Fig. 5. The relation between the reciprocal value of the time for half-maximal emergence and temperature for seed lot 1984—1 (○), 1980—2 (●), 1980 (□), 1979—1 (△) and 1979—2 (▲) at 5 temperatures in the phytotron.

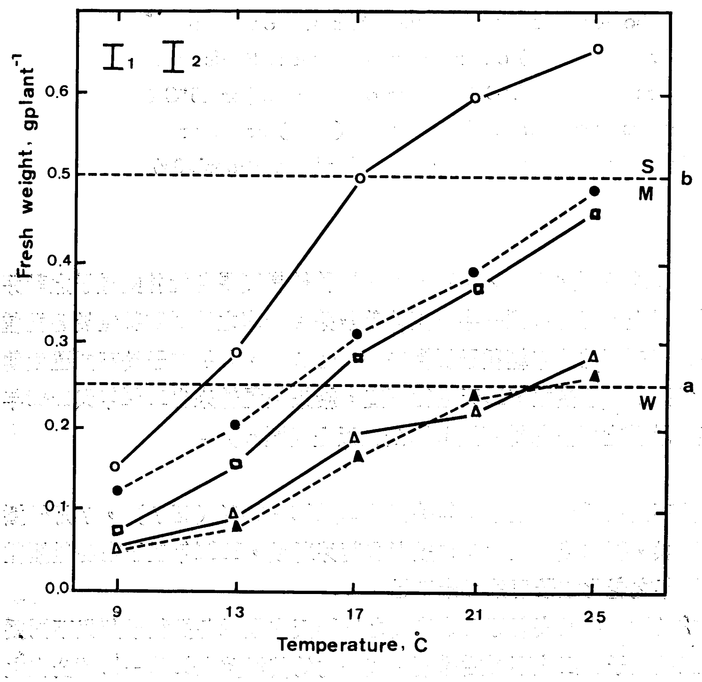

圖6. 溫度與五批甘藍種子在人工氣候室達一半最大幼苗萌芽百分率後第19天幼苗鮮重之關係，幼苗依其鮮重分類爲强 (S)，中 (M) 及弱苗 (W)，1984—1 (○)，1984—2 (●)，1980 (□)，1979—1 (△) 及 1979—2 (▲)。

Fig. 6. The relation between the mean fresh-weight of seedlings and the temperature in the phytotron for seed lot 1984—1 (○), 1984—2 (●), 1980 (□), 1979—1 (△) and 1979—2 (▲) at the 19th day after half-maximal seedling emergence. Seedlings were classified as strong (S), medium (M) and weak (W) according to fresh weight. $LSD_{0.05}$ for the the effect f temperature and seed lot is indicated by the vertical bars 1 and 2, respectively.

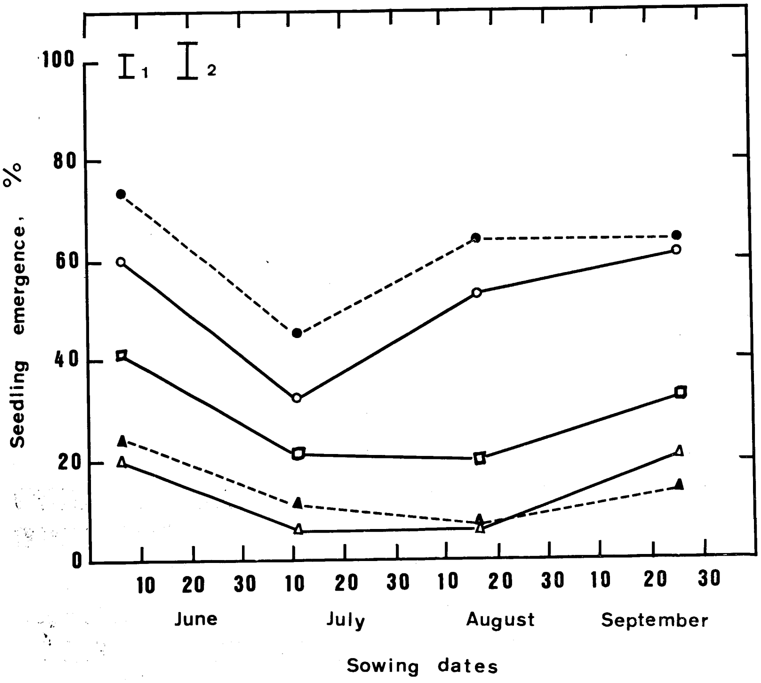

圖7. 播種時期與五批甘藍種子在田間之幼苗萌芽關係，1984—1（○），1984—2（●），1980（□），1979—1（△）及1979—2（▲）。

Fig. 7. The relation between seedling emergence and sowing date for seed lot 1984—1 (○), 1984—2(●), 1980 (□), 1979—1 (△) and 1979—2(▲)at field conditions. $LSD_{0.05}$ for sowing date and seed lot is indicated by the vertical bars 1 and 2, respectively.

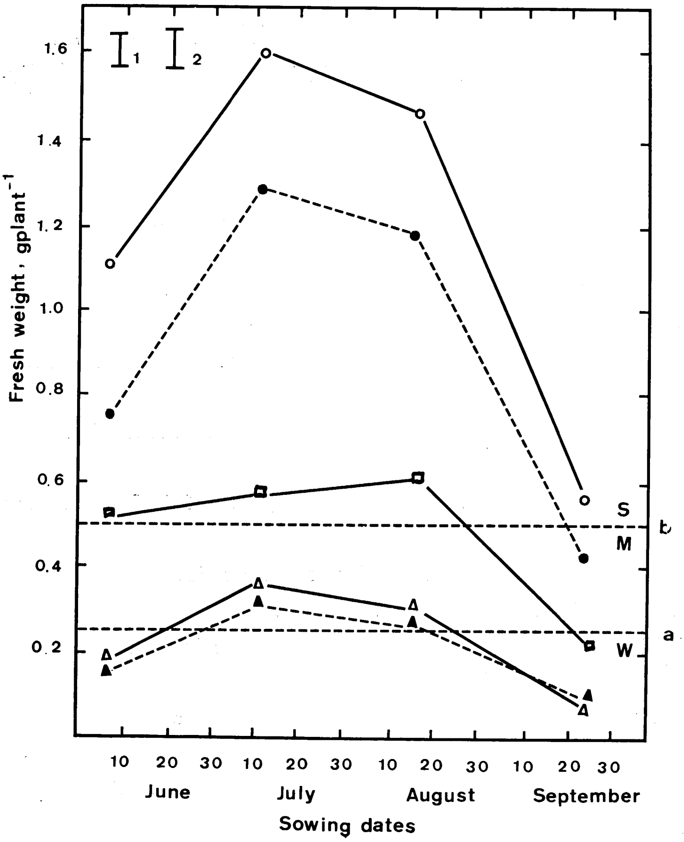

圖8. 播種時期與五批甘藍種子在田間達一半最大幼苗萌芽百分率後第19天幼苗鮮重之關係，幼苗依其鮮重分類爲强（S），中（M）及弱苗（W），1984—1（○），1984—2（●），1980（□），1979—1（△）及1979—2（▲）。

Fig. 8. The relation between mean fresh weight of seedlings and sowing date for seed lot 1984—1(○), 1984—2 (●), 1980 (□), 1979—1 (△) and 1979—2 (▲) at the 19th day after half-maximal seedling emergence in the field. Seedlings were classified as strong (S), medium (M) or weak (W) according to fresh weight. $LSD_{0.05}$ for sowing date and seed lot is indicated by the vertical bars 1 and 2, respectively.

討　論

試驗結果充分顯示不同批甘藍種子亦如其他作物種子，雖具好的發芽率，然而其活力却有很大的不同，像1979年種子，活力低，所得正常苗的百分率亦低（圖 1 ）。

調控劣變試驗（圖 4 ）亦充分揭露種子生理年齡之差異性，很明顯的1979年與1980年種子比1984年種子更接近種子存活曲線之急激降低點。1979年與1984年種子間之活力差異亦可由實驗室與人工氣候室不同溫度下種子之發芽與萌芽速率（圖 3 及 5 ），田間幼苗萌芽百分率（圖 7 ）及在實驗室標準發芽試驗（圖 1 ），人工氣候室（圖 6 ）及田間（圖 8 ）之萌芽等試驗之幼苗品質差異顯示之。

1980年的種子在調控劣變試驗中反應與1979年種子相似（圖 4 ），但在其他的試驗中則表現居中，因此，調控劣變試驗似會略爲低估了種子活力。

生理年齡之差異已在不同的試驗中顯示出，其結果與種子之眞正年齡大致成正相關關係。然而，其相關性並非直線，因爲在1979，1980與1984年三批種子之間，除了它們本身之儲存期各自相差達 6 年、 5 年與 1 年之外，採收前條件之差異與生產地區之不同也影響了種子之老化程度。1984與1979年分別產於不同地點之同年度兩批種子的發芽結果證實各批種子間之活力因地點之不同而有極爲顯著的差異，但是在1984年不同批種子之間的差異不同，1984—2之種子比1984—1者產生較多之幼苗但鮮重較低（圖 7 及 8 ），1984—1與1984—2間幼苗鮮重之差異與種子重量之差異有關（表 1 ）。

本試驗亦顯示除了種子之特性外，種子之萌芽與幼苗之品質極受周圍環境之影響。溫度是一突出的因子，降低溫度則減緩實驗室之發芽速率（圖 3 ）及人工氣候室之幼苗萌芽速率（圖 5 ）與幼苗鮮重；低溫亦可能是導致六月初旬田間試驗幼苗生長減緩之原因（圖 8 ），7 月份田間萌芽之減少可能係由於土壤表面形成硬殼所致。九月下旬則溫度與日長均不適合幼苗之生長。

由本試驗之結果所獲得之結論爲能發芽及能全然發芽之種子可能有相當不同之活力，低活力的種子表現出發芽速率減緩，幼苗鮮重較輕及不正常幼苗之數目增加。種子之低活力實爲導致田間生長不良之一主要原因。

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Aspects of Low Vigour of Cabbage Seeds

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Summary

Seeds of Brassica oleracea L. Capitata group cv. Oscar that had been commercially stored during 1 to 6 years showed almost full germination in a standard laboratory germination test at diurnal temperature of 20—30°C. Controlled deterioration of the seeds during 24 hours at 45°C and 24% seed moisture content revealed strong differences in seed vigour. Germination and emergence experiments at controlled conditions in laboratory or phytoron and in the field showed that low vigour was associated with reduced rate of germination and emergence, reduced seedling fresh weight and increased number of abnormal seedlings. Low vigour is one of the causes of low field emergence.

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中華農業研究 (Jour. Agric. Res. China) 38(4)438～445 (1989)

加工番石榴產期調節方法之研究[1]

王 武 彰[2]

摘要 本試驗以中山月拔五、六年生植株為供試材料，以尿素 (46%) 及益收生長素 (39.5%) 等二種藥劑噴施，二年試驗結果，發現在不同氣候環境下各處理間對促進落葉效果與產量有關。尿素25%試區，落葉率高，枝條損傷嚴重，影響萌芽及產量，而以尿素6.25%處理區較適宜，產量也高，平均落葉率達33.1%，新梢乾枯20.3公分，處理後12—14天即可萌芽，單株產量達39.8公斤，果粒重94.8公克，處理間增產45—51%。品質差異不甚顯著。

關鍵字：番石榴、尿素、益收、落葉、產期、產量、果實品質。

Key words：Guava、Urea、Ethel、Defoliation、Harvesting、Period、Productivity、Fruit quality。

番石榴為臺灣重要經濟果樹之一，產期長，產量高，富營養，果實除生食外，還可加工製罐，製果汁，風味清香可口，是夏季高級飲料之一，銷售量可觀。番石榴供加工主要品種為中山月拔，其果肉及製成果汁均為白色，芳香濃郁，與國外迥然不同。該品種主要產地集中在中部地區 (雲林縣斗六、斗南、林內等鄉鎮)，南部次之，目前栽培面積逐年增加中。中山月拔之栽培管理[2,3,5]，以往皆採用粗放式方法經營，以人工整枝修剪方法調節產期，致採果期無法集中，形成耗費人工，資本及無法配合工廠作業之困擾，加上產量與品質亦不甚穩定，造成市場競爭之隱憂，為解決上述經營方式之缺失，尋求經濟效益，提高農民所得起見，乃研究適宜藥劑配合處理，以促使整齊開花結果，節省勞力，資本與配合工廠作業為最終目標。

番石榴利用藥劑處理以達產期調節方法，據國外Chapman K. R. J. Savanah and B. Paxton氏1979試驗結果[10]，在澳大利亞以尿素25%濃度處理於密植番石榴幼年樹，可促使提早開花結果，產量比成年樹高出30—40%之巨，單株產量平均為 34.69公斤。產期由十五週縮短四週完畢，效果顯著。而王氏[7,8]於民國七十四、七十五年除以尿素外，還增加39.5%益收生長素 (Ethrel) 及95%高級夏油乳劑於臺灣氣候環境下使用，研究對加工番石榴整齊採收效果，結果發現尿素25%濃度處理部分，雖可達到效果，然其落葉率則平均高達 73.50%，且造成新梢損傷嚴重，乾枯程度為30—65公分之間，產量僅34.8公斤＼株。為減輕對植株產生傷害程度，及達產期調節目的，而尋求適宜臺灣氣候

1.臺灣省農業試驗所 研究報告第 1485 號。本試驗承行政院農業委員會補助77農建—7.1—糧—21(6)，謹此致謝意。

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環境下適當之濃度，以做爲將來提供果農之參考。

材料及方法

供試加工番石榴品種爲中山月拔，材料爲鳳山熱帶園藝試驗分所試區所種植之植株爲對象，整齊採收試驗除採用藥劑噴佈外，酌配合人工修剪操作，使用藥劑及濃度如下表：

處理代號	藥劑濃度	使用濃度
1	46%尿素	25%
2	46%尿素	12.5%
3	46%尿素	6.25%
4	39.5%益收生長素	0.4%
5	39.5%益收生長素	6.2%

以上兩種藥劑調配成五種濃度，每處理噴佈四株，合計20株，採用逢機區集排列，試驗自民國七十五年九月起至民國七十七年八月止計二年，每年噴佈時期分別爲九、十二、三及六月等各一次，每期噴佈後觀察落葉，萌芽，開花，着果情形，果實成熟調查產量與品質。所需調查項目如下：

1. 比較各種藥劑種類及使用濃度對處理效果之影響。
2. 調查時期對藥劑種類及濃度之效應。
3. 調查藥劑與濃度對植株之影響。
4. 調查萌芽，開花，着果期。
5. 調查產量及品質。

結果及討論

試驗採用尿素及益收生長素（Ethrel）兩種藥劑調配成五種濃度，分別於1986年9月16日、12月10日，1987年3月27日、6月15日、9月4日、12月15日，1988年3月24日，6月17日計二年，分八次之不同環境下實施，其間溫度變化情形與雨量分佈狀況如圖一：

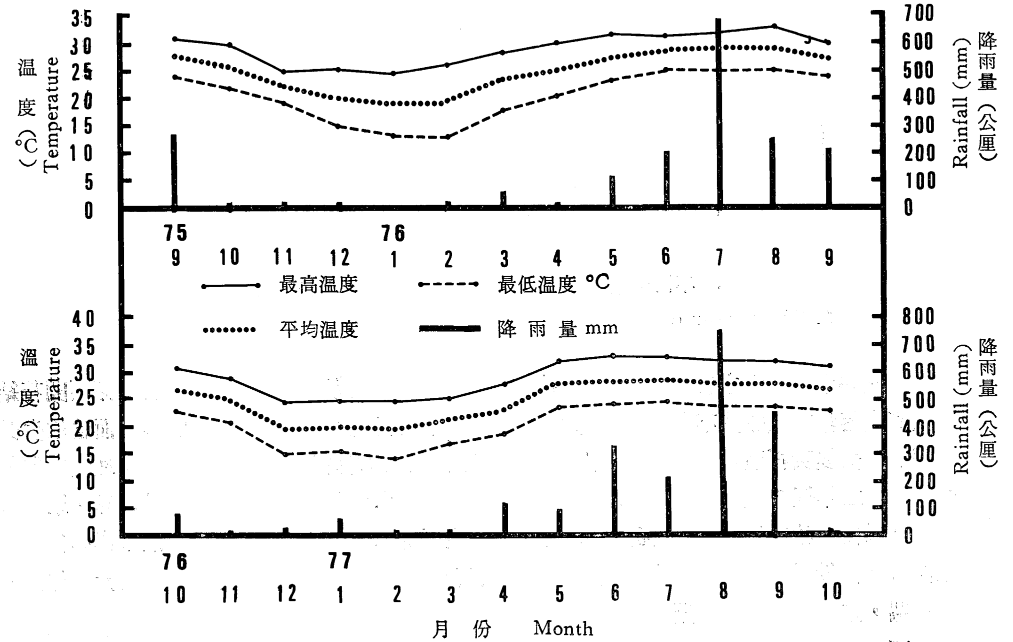

圖1. 試驗期間溫度及降雨量變化情形

Fig. 1. Variance of temperature and rainfall during the experimental period

由上述圖一所示，處理時期6、9月屬高溫期，最高溫度均在攝氏30°C 以上，12月至3月屬較低溫期，最高溫度均在30°C以下，平均溫度前者在24°C以上。雨量分佈主要集中於6～9月間。處理期間選擇當月之晴天上午實施，陰天及降雨均可能影響實施之效果。

本試驗採用藥劑及濃度於不同時期處理番石榴品種中山月拔5、6年生植株整株，對促進落葉效果與產量，品質之影響，經二年時間試驗調查，所得結果列述如下：

（一）藥劑處理對加工番石榴促進落葉之效果

本試驗藥劑採用尿素（46%）及益收生長素（39.5%）兩種，調配不同濃度於不同時期對番石榴植株處理，其對促進落葉效果，經調查所得結果平均如圖二所示：

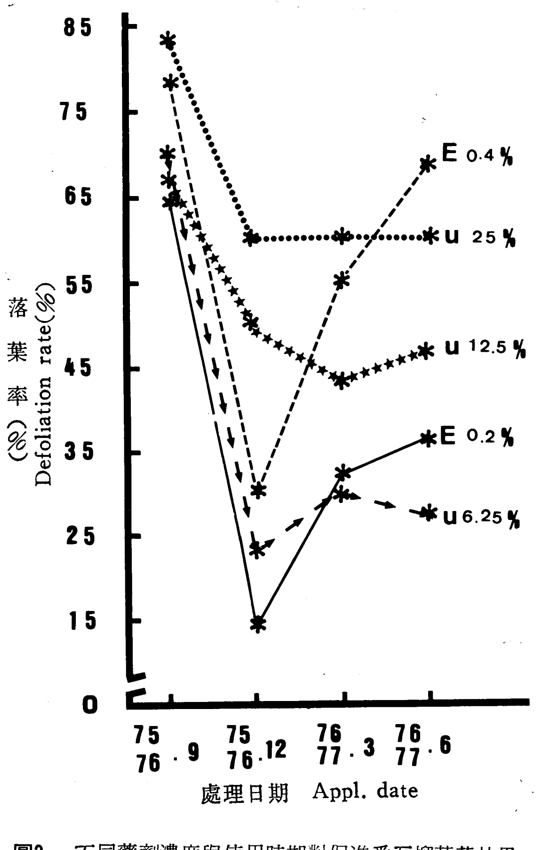

圖2. 不同藥劑濃度與使用時期對促進番石榴落葉效果

Fig. 2. The results of different chemical applications on guava defoliation

由圖顯示出最大之特色是番石榴植株葉片經藥劑處理後產生落葉，再重新萌芽而開花結果，其產生落葉方式迴然不同，尿素處理藥液噴佈後葉片產生創傷，乾枯再脫落，而益收生長素處理者，先變黃再產生離層脫落，上述藥劑經不同濃度噴佈後，其產生落葉率處理間有顯著不同效果，二年經八次調查所得平均：尿素25%濃度爲65.5%，尿素12.5%爲51.6%，尿素6.25%爲36.1%，益收生長素0.4%爲57.7%，益收生長素0.2%爲37.9%。當中以尿素25%最高，尿素6.25%較低，次爲益收生長素 0.2%，而落葉嚴重處理其葉片顯著減少，對光合作用產生正相關，進而影響萌芽時期及產量等。

不同季節對藥劑處理後產生落葉效果，濃度間也呈顯著差異，就以尿素6.25%而言，四個時期中落葉率最高爲9月份，達64.3%，次爲3月份29.8%，其次爲6月份27.0%，而以12月

份爲最低23.2%，由調查結果指出時期不同而言，溫度越高，其產生落葉效果則越佳，唯處理後如遇下雨則效果劇減。

（二）藥劑處理對加工番石榴植株之影響：

爲調節加工番石榴之產期，除利用人工修剪方法外以藥劑處理促使落葉，萌芽再開花結果，達整齊採收效果。然藥劑處理後是否對植株產生任何影響，本試驗利用藥劑處理後一個月時間詳加調查各處理濃度間及季節對植株新梢產生爲害程度，所得結果如圖三所示：

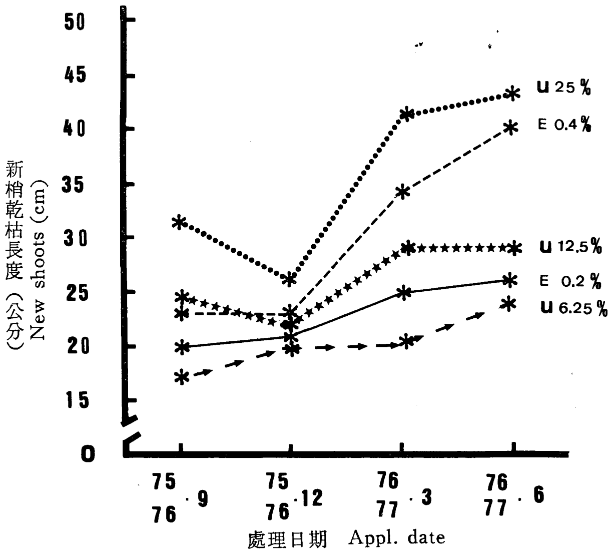

圖3. 不同藥劑濃度與使用時期對促進番石榴產生新梢乾枯情形

Fig. 3. The dieback length of new shoots after different chemical applications.

番石榴植株經藥劑處理後產生落葉隨著對新梢產生之影響，經本試驗調查所得結果，兩種藥劑五種不同濃度之藥液，經噴佈植株後，無論在任何季節下均對植株新梢產生乾枯情形，平均以尿素25%處理區，最高達 35.4公分長，次爲益收生長素 0.4%處理區爲 30.1公分，尿素12.5%爲26.3公分，益收生長素0.2%爲22.9公分，以尿素 6.25%處理較輕，僅達20.3公分，上述處理間經分析，結果達顯著差異。不同環境下對產生傷害程度，四個季節中，以6月份處理組較嚴重，就尿素25%濃度平均值而言，9月份爲31.5公分，12月份爲26.0公分，3月份爲41.0公分，6月份爲43.0公分。總之藥劑使用濃度對植株新梢產生爲害程度成正比關係。

（三）藥劑濃度對藥效及開花結果與採收之影響：

試驗爲瞭解各藥劑與濃度對番石榴植株產生藥效之時間及新梢發生後開花結果與採收情形，每次於藥劑噴佈後加以觀察記載，經調查結果如表一所示：

由調查得知各種藥劑不同濃度下經不同時期噴佈於番石榴植株上，其產生藥效最快者爲尿素處理區，尤以 25%濃度尿素噴佈後 5～10分鐘葉片即陸續呈現白色結晶絲密佈全葉表面，12.5%尿素則約在10～15分鐘後，尿素6.25%，約在15～20分鐘也同樣產生，氣候及濃度不同產生程度也不同，餘則無。

表1. 不同藥劑濃度與處理時期對番石榴開花及結果日期之影響

Table 1. The effects of different chemical applications on the flowering and fruiting dates of Guava

處理時期及調查項目 Chemical application & objects observed (days after application) / 處理別 Treatment	75.9 76.9 初期落葉 first sign of defoliation	萌芽期 bud sprout	着蕾期 flower bud appeared	開花期 Bloom	成熟期 Harvest	75.12 76.12 初期落葉 first sign of defoliation	萌芽期 bud sprout	着蕾期 flower bud appeared	開花期 Bloom	成熟期 Harvest	76.3 77.3 初期落葉 first sign of defoliation	萌芽期 bud sprout	着蕾期 flower bud appeared	開花期 Bloom	成熟期 Harvest	76.6 77.6 初期落葉 first sign of defoliation	萌芽期 bud sprout	着蕾期 flower bud appeared	開花期 Bloom	成熟期 Harvest
尿素 Urea 25%	2	14	18	37	133	3	26	40	92	194	5	12	24	52	151	2	11	31	62	145
尿素 Urea 12.5%	2	14	18	37	133	3	26	30	77	194	5	12	25	52	153	2	14	31	62	145
尿素 Urea 6.25%	3	14	20	41	133	4	14	29	78	194	5	12	29	53	153	2	14	35	62	154
益收生長素 Ethrel 0.4%	2	14	20	44	133	3	16	37	90	201	5	27	43	65	156	2	14	29	57	145
益收長生素 Ethrel 0.2%	2	14	18	43	133	4	26	58	99	205	5	27	40	62	153	2	14	29	56	140

不同氣候條件下其萌芽速度各異，依調查所得結果，四個時期上，以3月最短在12～27天左右即萌芽，次爲6月，9月在14天左右，而以12月份較慢，達14～26天之間。處理後至成熟期也產生差異，四個時期中，以9月份者最短約在 133天左右，次爲6月份，140～154天之間，最長者爲12月份，達194～205天之間。概因此時溫度較低，日然短且弱之故。因此落葉率與損傷程度均對萌芽、開花結果及成熟時間有關。

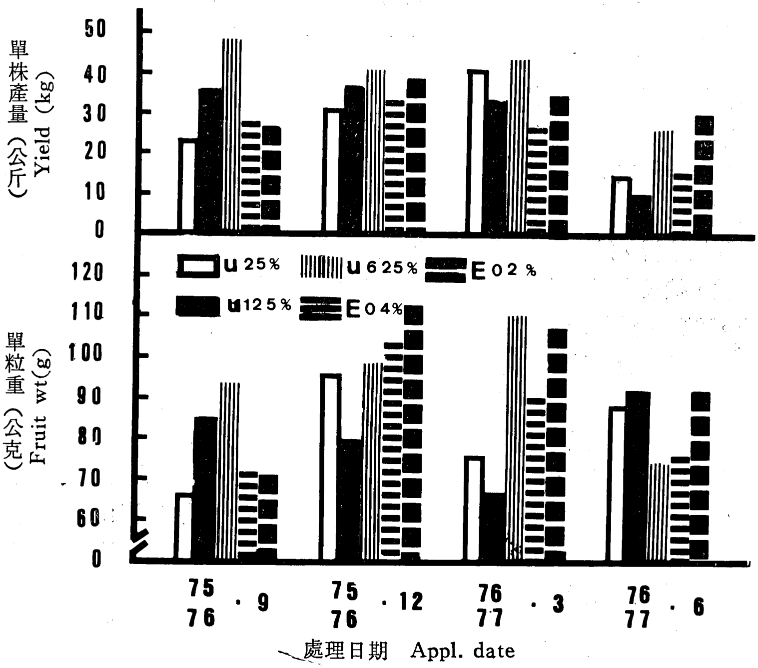

圖1. 不同藥劑濃度與時期對番石榴平均產量差異

Fig. 4. The average yields of guava after different chemical applications.

（四）藥劑及濃度處理對產量之影響：

藥劑及濃度對番石榴雖可達產期調節效果，然與產量是否有關，經本試驗二年間之探討結果，各處理間所得結果如圖四：

由圖所示得知，供試藥劑對番石榴產量由二年平均所得，五種處理中以尿素6.25%處理區最高達 39.8公斤，次爲益收生長素0.2%處理區33.0公斤，再次爲尿素12.5%處理區29.5公斤，尿素25%處理區27.5公斤，而益收生長素0.4%處理區最低，僅 26.3公斤。平均果重方面，以尿素6.25%及益收生長素0·2%處理區較高，各達94.8公克及96.3公克，次爲益收生長素0.4%處理區86.0公克較低者爲尿素25%及12.5%處理區僅31.8及81.8公克。

（五）藥劑與濃度對不同時期品質之影響：

試驗爲明瞭藥劑對番石榴產期調節利用之效益外，進而探求其果實品質變化情形，經本試驗調查所得結果，如圖五所示：

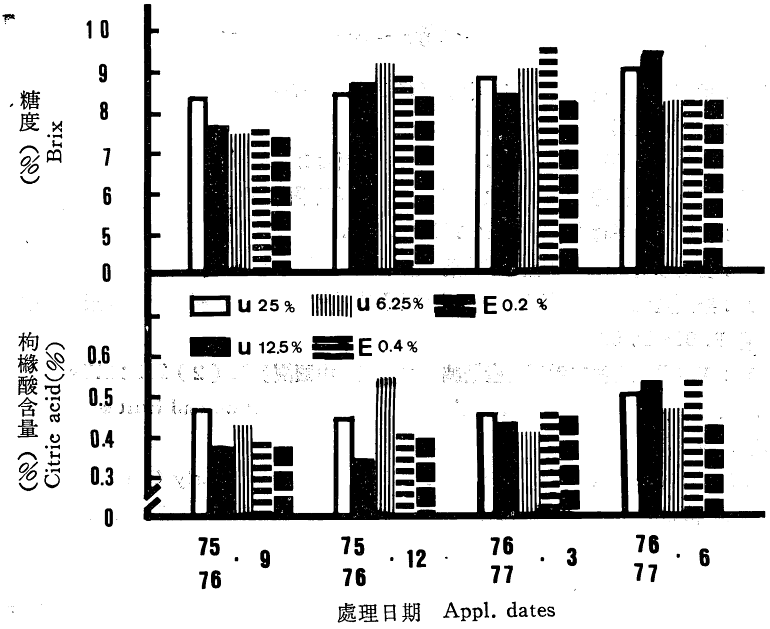

圖5. 不同藥劑濃度與時期對番石榴品質之差異

Fig. 5. The fruit quality of guava after different chemical applications.

加工番石榴植株經不同藥劑及濃度在不同季節上處理後，開花結果，所得果實之糖度經二年之調查，處理間經四個時期處理後所得平均；尿素25%濃度處理區爲9.6%，尿素 12.5%濃度處理區爲9.2%，尿素6.25%濃度處理區爲9.2%，益收生長素0.4%處理區爲9.1%，益收生長素0.2%處理爲9.0%。而時期之差異就以尿素6.25%濃度處理區而言，九月份者爲 9.6%，十二月份爲9.2%，三月份爲10.5%，六月份爲8.5%，就中以三月份處理者較高，而處理間經鄧肯式變方分析所得結果，未達差異顯著之標準。

而枸櫞酸含量處理間平均：尿素25%處理區爲0.52%，尿素12.5%處理區爲0.49%，尿素6.25%處理區爲0.48%益收生長素0.4%處理區爲0.49%，益收生長素0.2%處理區爲0.48%。不同季節與處理間而論，以十二月份處理者有顯著差異，餘不顯著。若以尿素 6.5%濃度處理區爲準，九月份爲0.57%，十二月份爲0.55%，三月份爲0.40%，六月份爲0.41%。就中以九、十二月份爲高，三、六月份所採果實含量低。

結果與建議

臺灣加工番石榴之管理，以往均採用粗放式經營，利用人工整枝與修剪方式調節產期，致產期無法集中，配合工廠作業，造成兩者重大損失。為解決上述缺失，而研究以藥劑處理調節其產期。據王氏以往利用尿素，益收生長素及高級夏油乳劑等三種噴施結果，以尿素 12.5%及益收生長素0.2%濃度比其他處理區為佳[7,8]，然尿素12.5%濃度若於臺灣高溫多濕氣候環境下，對植株產生落葉與新梢損傷仍大，為進一步深討，於民國七十五年九月起連續二年試驗調查結果，證實以尿素6.25%處理者比12.5%濃度者為佳，次為益收生長素0.2%濃度。而以6、9月高溫處理區萌芽快。

番石榴之開花結果習性與檬果、荔枝、蓮霧、楊桃等果樹不同，其花蕾大都着生於剛萌發新梢之第二至四對葉片葉腋間，而成熟枝條若有則於枝之先端新梢或後期再萌發之新梢上，否則因生長旺盛而較少，此現象與黃氏[1] 之調查相吻合。本試驗之對照組因採用放任自然生長，落葉及萌芽機率少，若有着果數量亦少且零星，無法配合試驗時間，致對照區未列入比較。

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The Studies on the Methodology of Regulation of Harvesting Perids in Processing Guava

U-Chang Wang

Summary

In this study, the processing Guava, Five or six years old of Chung Sun Yueh Pa, and two chemicals, 46% Urea and 39.5% Ethrel, were used. The results from two-year experiments revealed that different applicationtimings and chemical concentrat onis were closely related to defoliation and production of processing guava under different climate conditions. New shoots were caused severe defoliation and injury, and productivity was also low when 25% urea was applied. 6.25% urea was the best concentration with 36.1% defoliation and only 20.3cm dieback on new shoot. Buds initiated again 12—14 days after spraying of 6.25% urea. Yield of year was 39.8kg per tree with a average of 94.8g per fruit in 6.25% urea treatment, resulting a 45—51% yield increase compared to other treatments. Difference of fruit quality between treatments was not significant.

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嵌紋病對玉米生育之影響及篩選抗病品系應用於田間之效益[1]

鄧汀欽　楊一郎　蔡淑娓[2]

摘要　B型玉米矮化嵌紋病毒（MDMV-B）及A型、B型、D型、兩耳草（sourgrass）型及 S—1 分離株甘蔗嵌紋病毒（SCMV）都是玉米嵌紋病的病原，經以酵素連結抗體免疫分析（ELISA）從1983年至1988年調查之結果，以 MDMV-B 在田間發生的頻度最高；再經溫室苗期測定病原性及田間試驗評估各型病毒所造成的經濟爲害度，亦以 MDMV-B 最爲顯著。裂區設計的田間試驗比較MDMV-B接種與不接種的玉米之生育狀況，結果在預備試驗中統計分析病毒感染所造成的間接影響並不顯著，因此本研究的主要試驗都只比較病毒接種的直接效應。從1986年至1988年，三次田間試驗之結果，發現MDMV-B感染顯著影響玉米生長並造成嚴重減產，最高可達47.9%，一般推廣之飼料玉米減產22—29%，臺農1號減產則在20%以下，明顯異於感病品種之反應。從1983年至1989年共篩選 2808個玉米品系僅11個呈抗病反應，172個呈中抗反應，324個呈中感反應，餘皆爲感病反應者。選其中呈不感病反應的八個青割玉米品系進行田間試驗，其生長與產量較不受 MDMV-B的影響，結果與感病的對照有明顯差異。選育中的超甜玉米品系七個，經田間試驗證實 MDMV-B感染後，株高、莖軸、產量等均明顯受損，且品種間反應程度有差異。

臺灣目前已發生的B型玉米矮化嵌紋病毒（B strain of maize dwarf mosaic virus）(3)、A型，B型、D型、兩耳草（sourgrass）型及 S—1 分離株的甘蔗嵌紋病毒（Sugarcane mosaic virus）(1,2,3,7) 都可感染玉米造成嵌紋病徵。田間試驗證實玉米品種間對 B 型玉米矮化嵌紋病毒（MDMV-B）的反應有顯著差異(5)，因此利用玉米的遺傳特性來防治嵌紋病是確實可行的。本研究即在探討不同型的病毒對玉米生長與產量之影響，挑出主要病原，進行田間試驗，調查病毒感染對不同遺傳型玉米之影響，及評估歷年篩選的抗病品系應用於田間之效益。

材料與方法

一、玉米嵌紋病之病原類型調查

利用先前製備的 MDMV-B 和甘蔗嵌紋病毒 S—1 分離株（SCMV-S-1）之抗血淸(4)，以酵素連結抗體免疫分析法（Enzyme-linked immunosorbent assay, ELISA）檢定全省各玉米產區所發生類似玉米嵌紋病的病株，判定其病原是何種病毒系統（strain），從 1983年至1988年，調查田間所發生的病原類型，監視其消長狀況，以擬訂防治對策。

二、各型病毒系統對玉米的病原性與經濟爲害程度之比較

收集各型病毒系統，包括 MDMV-B(3)，SCMV-S-1(4)，A型甘蔗嵌紋病毒（SCMV-A）(2,4)，

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B型甘蔗嵌紋病毒（SCMV-B）[2,4]，D型甘蔗嵌紋病毒（SCMV-D）[2,4]，及兩耳草（sourgrass）型甘蔗嵌紋病毒（SCMV-Sou）[7] 等六種，接種保存於臺南5號玉米供做接種源（inocula），試驗時以超甜玉米 Honey 236 爲供試品種，播植於溫室盆栽，發芽後3～4葉時，同時以各型病毒感染之臺南5號玉米粗汁液分別磨擦接種，以後逐日觀察病徵，記錄發病率，以病勢發展判定各型病毒系統對玉米的病原性。此外，於本所50號田進行試驗，評估不同病原性的各型病毒系統對玉米生育之影響，田間試驗採完全逢機區組設計（RCBD），以各型病毒接種爲處理，不接種的試區爲對照，三重覆，試區爲二行區，行長7公尺，行株距75×50公分，播種後一週進行病毒接種，以各接種源粗汁液逐株磨擦供試植株葉片，隔一週後未出現病徵者再接種一次。田間管理按一般超甜玉米之栽培方式，開花後即行調查株高，收穫後量取穗重，進行統計分析。

三、田間試驗中病毒感染對玉米生育之直接與間接影響之評估

採裂區設計於本所50號田進行田間試驗，以玉米品種爲主區，內有三個副區，分別是三種處理，一如前述方法接種 MDMV-B，一爲不接種病毒但試區內各行都與接種病毒的植株相鄰， 另一爲不接種病毒且與罹病株隔離。供試玉米品種（系）有六：超甜 Honey 236、臺南16號、臺農351、臺農1號、 TA80—1410、 TA85W-2；試驗調查項目有莖軸、株高、鮮果穗產量，乾子粒產量等，各副區逢機取樣10株，取平均值進行統計分析。

四、MDMV-B 感染對玉米產量之影響

從1986年到1988年每年秋作種植上述六個玉米品種（系）評估MDMV-B 對各個玉米品種（系）的產量之影響，1986年在本所4號田試驗，試區行長6公尺，行株距75×50公分，1987年在50號田試驗，試區行長7公尺，行株距75×50公分，1988年在50號田試驗，試區行長6公尺，行株距85×30公分，每年試驗皆採同樣的裂區設計，以玉米品種爲主區，內有二個副區，一接種 MDMV-B，一爲不接種的對照區，收穫時每副區逢機取樣10株調查鮮果穗產量，再經充分曝曬脫粒後稱取子粒重，統計分析比較各品種受 MDMV-B影響的程度。

五、玉米分離品系對 MDMV-B 的抗病篩選

利用先前發展的溫室苗期抗病檢定方法[3]， 對本所農藝系提供的各項來源之玉米分離品系， 在溫室內以 MDMV-B 接種，進行抗病檢定，由病勢發展評斷各分離品系之抗病等級，篩選出具有抗性之品系，以進一步試驗。

六、從青割玉米中篩選之抗病品系應用於田間對 MDMV-B 的反應

農藝系提供選育中的18個青割玉米品系，經前述抗病檢定後，篩選出8個較具抗性的品系（南改育 SI-1, SI-2, SI-3, SI-4, E-8, H-8, H-9, E-9）和1個感病品系（86SI-8），以臺南5號爲感病對照，進行田間試驗。1988年9月20日播種於本所50號試驗田，採用裂區設計，玉米品種（系）爲主區，MDMV-B 接種與否爲副區，單行區，試區行長6公尺，行株距 85×30 公分，成熟時每副區逢機取樣5株以供調查，三重覆，調查項目有株高、鮮果穗產量及乾子粒產量等，至於減產率則係三個區組的平均值，而每個區組的減產率則係對照不接種的副區時，各品種（系）接種病毒後產量減少的百分率。

七、選育中之超甜玉米品系對 MDMV-B 之反應

供試材料爲本所農藝系目前選育中之超甜玉米品系，包括有 SD10, SH10×H, SH7×H, SD7, M2, M, BT2 等七個，加上臺南15號和 Honey 236 爲對照，進行裂區設計的田間試驗，以品種（系）爲主區，接種 MDMV-B 與否爲副區，與上述相同的方法進行測驗分析，比較超甜玉米品系間對 MDMV-B 感染後反應的差異性。

結　果

一、玉米嵌紋病之病原類型調查

從1983年至1988年共調查全省108處，採集737個疑似玉米嵌紋病的檢體標本，以 ELISA 篩檢其中的病毒類型，結果如表一所示，每年都是以 MDMV-B 單獨感染發生頻度最高，達 73.3%，證實截至目前仍是以 MDMV-B 爲玉米嵌紋病的主要流行病毒系統。

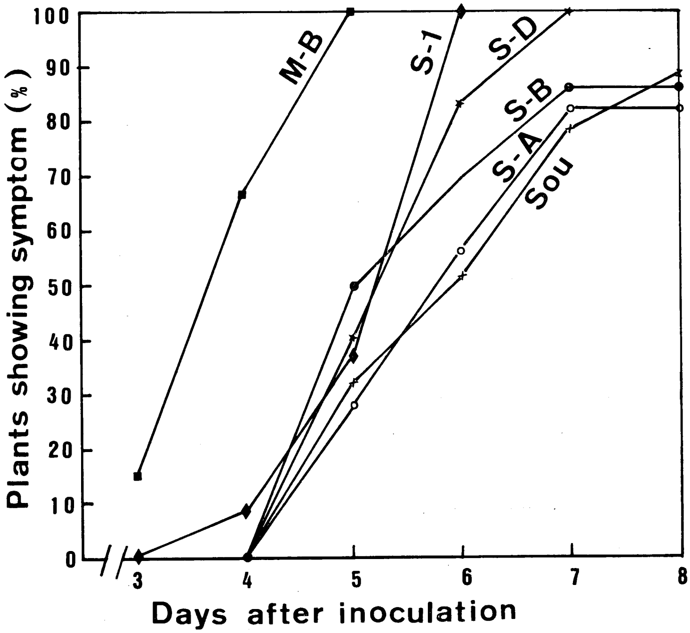
表1. 歷年調查造成玉米嵌紋病之B型玉米矮化嵌紋病毒 (MDMV-B) 與各型甘蔗嵌紋病毒 (SCMV) 在臺灣玉米產區之發生

Table 1. Survey of strains of sugarcane mosaic virus (SCMV) and B strain of maize dwarf mosaic virus (MDMV-B) occurred on corn producing areas of Taiwan in previous years.

Year	No. of sampled field	No. of MDMV-B	No. of SCMV	No. of MDMV-B+SCMV	No. of others	Total
1983	2	1	0	0	1	2
1984	18	20	0	1	10	31
1985	39	140	5	7	50	202
1986	41	351	28	22	53	454
1987	4	14	0	0	3	31
1988	4	14	3	8	6	17
Total	108	540	36	38	123	737
%		73.3	4.9	5.2	16.7	

二、各型病毒系統的病原性與經濟爲害程度之比較

1.超甜玉米 Honey 236 分別接種各型病毒系統後，其病勢的發展如圖一所示，MDMV-B接種



圖一、MDMV-B (M-B), SCMV-S-1 (S-1), SCMV-D (S-D), SCMV-B (S-B), SCMV-A (S-A), 及 SCMV-Sou (Sou) 接種超甜玉米 'Honey236' 病勢發展之比較.

Fig. 1. Comparisons of disease developments of sweet corn 'Honey 236' inoculated with MDMV-B (M-B), SCMV-S-1 (S-1), SCMV-D (S-D), SCMV-B (S-B), SCMV-A (S-A), and SCMV-Sou (Sou) respectively.

後 3 天即開始出現病徵，5 天即 100%發病，其病原性顯然特別高，至於其他各型病毒的病原性大小依序是 SCMV-S-1, SCMV-D, SCMV-B, SCMV-A 及 SCMV-Sou。

2.由表二變方分析結果顯示，玉米株高因病毒感染的類型不同而有顯著性差異，鮮果穗產量方面則有極顯著的差異。再根據表三所示，病毒感染對超甜玉米的生育均有影響，尤其 MDMV-B 感染所造成的效果明顯異於其他病毒系統，對鮮果穗的產量影響極大，所以比較各型病毒系統對玉米的經濟爲害程度，仍是以 MDMV-B 爲首要，防治上應針對於此。

表2. 超甜玉米 'Honey 236' 株高及鮮穗產量受各型病毒感染之影響經變方分析所得均方值

Table 2. Mean squares from the analys's of variance for plant height and green ear yield of sweet corn 'Honey 236' infected by different viruses.

變異原因 Source of variance	自由度 Degree of freedom	株高 Plant height	鮮穗產量 Green ear yield
區組 Block	2	39.06	673.54
病毒類型 Viruses	6	90.16*	1,087.24**
機差 Error	12	27.01	157.21

*, **Significant at the 0.05 and 0.01 probability level, respectively.

表3. 各型病毒系統對超甜玉米 'Honey 236 生育之影響

Table 3. Effects of different viruses on growth and yield of sweet corn 'Honey 236

病毒種類 Strains/isolate of virus	株高 (cm) Plant height	單株鮮穗產量 (g) Green ear yield/plant
B strain of maize dwarf mosaic virus	76.33 c[1)]	119.67 c
A strain of sugarcane mosaic virus	85.60 abc	149.67 b
B strain of sugarcane mosaic virus	85.10 abc	149.67 b
D strain of sugarcane mosaic virus	83.60 abc	143.50 bc
Sourgrass strain of sugarcane mosaic virus	86.93 ab	140.33 bc
S-1 isolate of sugarcane mosaic virus	78.30 bc	127.33 bc
Noninoculated control	92.75 a	179.03 a

1) Data are means of 30 plants (10 plants per plot), experiment was a randomized complete block design (RCBD) with three replicates, values in each column having common letters are not significantly eifferent, (P=0.05)

三、田間試驗中病毒感染對玉米生育之直接與間接影響之評估

由表四變方分析結果顯示，除了品種的效應，在株高、鮮穗產量、乾子粒產量方面均有 1 %極顯著差異外，接種處理的效應在各方面也都有極顯著的差異。但是比較接種處理所造成的直接與間接效應，如表五所示，雖然不接種 MDMV-B 的試區之試驗結果均明顯異於接種的試區，但是其中與病毒相鄰的試區和與病毒隔離的試區之試驗結果比較並無顯著差異。因此在往後的試驗中，均只設計比較病毒接種與否的效應，而省略其中的一些間接效應，以簡化試驗之進行。

四、MDMV-B 感染對玉米產量之影響

表4. B型玉米矮化嵌紋病毒感染對玉米生育之直接與間接影響經變方分析所得均方值

Table 4. Mean squares from the analysis of variance for direct and indirect effects of B strain of maize dwarf mosaic virus on developments and yields of sweet corn 'Honey 236'.

變異原因 Source of variance	自由度 Degree of freedom	株高 Plant height	單株鮮穗產量 Green ear yield/plant	每公頃子粒產量 Grain yield/ha.
區組 Block	2	85.19	1,953.18	128,834.88
品種 Variety (V)	5	7,178.59**	117,261.90**	25,033,754.42**
主區機差 Error A	10	48.62	2,561.48	324,292.09
接種處理 Treatment (T)	2	1,461.75**	20,828.43**	2,492,515.48**
品種×處理 V×T	10	16.80	3,126.35*	175,702.81
副區機差 Error B	24	27.52	1,004.01	112,122.63

*, **Significant at the 0.05 and 0.01 probability level, respectively.

表5. B型玉米矮化嵌紋病毒感染對不同玉米品種生育之直接與間接影響

Table 5. Direct and indirect effects of B strain of maize dwarf mosaic virus infection on developments and yields of different corn varieties.

品系/品種 Varieties/lines	處理 Treatments[1)]	株高 (cm) Plant height[2)]	單株鮮穗產量 (g) Green ear yield/plant	每公頃子粒產量 (kg) Dry grain yield/ha.
Honey 236	I	78.73 b	112.17 a	200.89 a
	I/N	91.47 a	144.00 a	328.89 a
	N	94.17 a	132.33 a	311.11 a
Tainan 16	I	143.47 b	244.67 b	2,853.34 b
	I/N	161.00 a	281.67 ab	3,529.78 a
	N	161.70 a	306.00 a	3,760.89 a
Tainung 351	I	143.77 b	319.00 c	2,850.67 c
	I/N	160.10 a	483.33 a	4,183.45 a
	N	158.43 a	398.67 b	3,582.23 b
TA80—1410	I	104.57 b	133.00 a	582.22 b
	I/N	127.60 a	186.83 a	1,208.89 a
	N	124.80 a	184.00 a	1,022.22 ab
TA85W-2	I	143.07 b	300.00 b	3,936.89 b
	I/N	154.97 a	372.00 a	4,470.23 ab
	N	154.47 a	326.00 ab	4,794.67 a
Tainung 1	I	149.73 b	359.67 b	3,186.67 b
	I/N	161.60 a	379.00 b	3,912.89 a
	N	163.67 a	434.67 a	3,822.23 a
Mean	I	127.22 b	244.75 b	2,263.45 b
	I/N	142.79 a	303.64 a	2,939.86 a
	N	142.87 a	296.94 a	2,882.23 a

1) I : Inoculated ; I/N : Noninoculated but adjoining inoculated plots ; N : Noninoculated.
2) Data are means of 30 plants (10 plants per subplot), experiment was a split-plot design with corn varieties as main plots and treatments as subplots with three replicates of each plot, values in each item having same letters are not significantly different. (P=0.05)

三年田間試驗結果如表六所示，MDMV-B 感染對玉米產量有顯著影響，但是影響的程度隨玉米品種而異，自交系 TA80—1410 所受影響最大，可達47.9%的子粒減產率，其次是超甜玉米 Honey 236，其鮮果穗減產可達31.9%，乾子粒減產可達36.8%，一般飼料玉米臺南16號和臺農351號則有約22—29%的減產率，臺農 1 號却明顯異於其他供試品種，對 MDMV-B表現出特殊的耐病性，其減產率在20%以下，與感病品種有顯著性差異。

表6. B型玉米矮化嵌紋病毒感染對各個玉米品種（系）產量之影響

Table 6. Effects of infection of B strain of maize dwarf mosaic virus on yields of different corn varieties (lines).

玉米品系／品種 Corn lines/varieties	處理 Treatment	單株鮮穗產量 (g/plant) Green ear yield			每公頃子粒產量 (kg/ha.) Dry grain yield			減產率 Percentage of yield loss					
								鮮果穗 Green ear			乾子粒 Dry grain		
		1986—87 [1]	1987—88 [2]	1988—89 [3]	1986—87	1987—88	1988—89	1986—87	1987—88	1988—89	1986—87	1987—88	1988—89
Honey 236	I [4]	194.00 [5]	112.17	161.67	942	201	1,249	31.91 a [6]	17.73 ab	22.89	36.79 ab	35.80 ab	35.08 ab
	N	289.67*	138.17	209.67*	1,533	320	2,014*						
Tainan 16	I	271.50	244.67	237.67	3,431	2,853	4,495	27.21 ab	16.78 ab	21.76	26.88 ab	21.90 bc	24.15 ab
	N	374.17**	293.83*	306.00**	4,742	3,645**	5,958**						
Tainung 351	I	291.50	319.00	225.17	3,818	2,851	3,479	24.95 ab	27.78 a	25.32	29.27 ab	26.42 bc	27.25 ab
	N	387.33*	443.50**	302.33**	5,422*	3,885**	4,885**						
TA80—1410	I	131.67	133.00	138.33	1,107	582	790	30.19 ab	28.29 a	28.89	39.81 a	47.93 a	41.21 a
	N	188.83	185.42*	198.83**	1,867	1,116*	1,343						
TA85W-2	I	286.83	300.00	253.50	4,089	3,937	3,838	18.17 ab	13.94 ab	15.33	24.18 ab	14.01 c	21.94 ab
	N	354.17	349.00*	298.33*	5,418	4,633**	4,907**						
Tainung 1	I	379.33	359.67	296.50	5,645	3,187	5,400	2.65 b	10.24 b	19.87	1.24 b	17.10 c	20.40 b
	N	394.17	406.83*	369.83**	5,942	3,868**	6,783**						
Mean	I	259.14	244.75	218.81	3,172	2,269	3,208	22.51	19.12	22.34	26.36	27.19	28.34
	N	331.39**	302.79**	280.83**	4,154**	2,911**	4,315**						

1) Planted on September 30, 1986, in experimental field no. 4, plant spacing 75×50cm. Data adopted from previous report (5).
2) Planted on October 9 1987, in experimental field no. 50, plant spacing 75×50cm.
3) Planted on September 20, 1988, in experimental field no. 50, plant spacing 85×30cm.
4) I : Inoculated with B strain of maize dwarf mosaic virus. N : Noninoculated.
5) Data are means of 30 plants (10 plants per subplot). Experiment was a split-plot design with corn varieties as main plots and treatments as subplots, with three replicates of each plot. *, **=Significantly different form corresponding control at 5% and 1% levels, respectively.
6) Data are means of three blocks, values in the column with same letters are not significantly different. (P=0.05)

五、玉米分離品系對 MDMV-B 的抗病篩選

過去五年檢定各種玉米分離品系對 MDMV-B 的抵抗性，其結果列於表七，其中具有抗病基因的品系之比率並不高，尤其超甜玉米的分離系中更難發現具有抗病性者。至於這些抗病品系是否都能直接應用到田間，則需要進一步觀察。

表7. 各種玉米分離品系對玉米矮化嵌紋病毒 B 型系統抗病篩選之結果

Table 7. Results of screening for resistance of different corn isolines to B strain of maize dwarf mosaic virus.

年份 Year	分離品系之來源 Origin of isoline	玉米品系數 No. of corn lines			
		抗病 Resistant	中抗 Moderately resistant	中感 Moderately susceptible	感病 Susceptible
1983—84	飼料玉米 Feed	8	50	69	489
1985—87	飼料玉米 Feed	2	109	206	1,412
1985—86	超甜玉米 Sweet	0	9	26	625
1987—88	超甜玉米 Sweet	1	1	19	271
1988—89	青割玉米 Silage	0	3	4	11

六、從青割玉米中篩選之抗病品系應用於田間對 MDMV-B 的反應

18個青割玉米品系利用溫室苗期法抗病檢定之結果列於表八，其中顯示整個供試的玉米族羣中具有一些抗病基因存在，使其病害指數低於對照組的 100。選出其中抗病等級呈不感病的八個品系進行田間試驗，其結果與 1 個感病的品系 (86SI-8) 及臺南 5 號對照經統計分析如表九，可見這些較具抗性的品系應用到田間後，生長與產量較不受 MDMV-B 的影響，其結果與對照組有明顯差異。尤其南改育 SI-4 及H-8 (SW560×Hi31) 兩個品系幾不因 MDMV-B 感染而減少產量。

表8. 青割玉米品系對 B 型玉米矮化嵌紋病毒抗病篩選之結果 1)

Table 8. Results of screening for resistance of silage maize lines to B strain of maize dwarf mosaic virus.

品系／品種 Lines/Varieties	感染率 (infection percentage) 2)			病害指數 Disease index	抗病等級 Rating 3)
	6D. A. I.	13D. A. I.	18D. A. I.		
南改育 SI—1	50	50	83	67	MS
南改育 SI—2	17	67	83	63	MS
南改育 SI—3	17	83	83	67	MS
南改育 SI—4	0	67	67	50	MR
E—7 (SW558×B77)	83	100	100	95	S
E—8 (SW560×B77)	17	50	50	42	MR
E—9 (SW562×B77)	67	83	83	92	S
E—47 (SW658×B77)	83	100	100	96	S
H—7 (SW558×Hi31)	33	100	100	83	S
H—8 (SW560×Hi31)	50	50	50	50	MR
H—9 (SW562×Hi31)	17	67	83	63	MS
H—41 (SW646×Hi31)	50	100	100	88	S
85W-8 (ICAL221×B77)	100	100	100	100	S
86SI—6 (Antiqua-2D×SR52F)	100	100	100	100	S
86SI—8 (Antiqua-2D×Hi31)	100	100	100	100	S
臺農 1 號 (ICAL210×Hi31)	100	100	100	100	S
臺農351 (TA80—2598×TA80—1410)	100	100	100	100	S
臺南白 (Tainan white, local)	100	100	100	100	S
臺南 5 號(Tainan 5, susceptible CK)	100	100	100	100	S

1) Tested by greenhouse seedling technique, criteria for disease index and for rating are according to previous report(3).
2) D. A. I.: Days After Inoculation.
3) MR: Moderately Resistant, MS: Moderately Susceptible, S: Susceptible.

表9. 篩選之青割玉米品系生育受 B 型玉米矮化嵌紋病毒之影響

Table 9. Effects of B strain of maize dwarf mosaic virus on developments and yields of selected lines of silage maize.

玉米品系／品種 Corn lines/varieties	處理 Treatment	株高 (cm) Plant height	單株鮮穗產量(g) Green ear yield/plant	每公頃子粒產量 (kg) Grain yield/ha.	減產率 (%) Yield loss
南改育 SI—1	I [1)]	168.67 [2)]	270	4,278.6 [3)]	7.44 [4)]
	N	165.00	301	4,833.4	
南改育 SI—2	I	172.80	271	4,699.7	14.37
	N	177.27	326	5,664.7	
南改育 SI—3	I	159.33	299	4,841.0	15.61
	N	167.80	341	5,567.7	
南改育 SI—4	I	171.07	318	5,060.8	0.47
	N	170.00	327	5,164.5	
E—8 (SW560×B77)	I	160.53	269	4,026.0	8.37
	N	152.87	313	4,568.9	
H—8 (SW560×Hi31)	I	174.80	311	5,333.0	2.53
	N	187.73	321	5,644.6	
H—9 (SW562×Hi31)	I	163.73	212	4,188.4	14.34
	N	167.73	259	5,036.1	
E—9 (SW562×B77)	I	169.60	269	4,952.2	19.25
	N	187.33	340	6,095.0	
86SI—8 (Antiqua-2D×Hi31) (Susceptible-CK)	I	149.73	201	3,105.9	34.75
	N	172.23*	259	4,838.4*	
臺南5號 (Tainan 5, CK)	I	124.13	100	2,338.5	36.30
	N	146.73*	150	3,713.9	

1) I: Inoculated with B strain of maize dwarf mosaic virus. N: Noninoculated.

2) Data are means of 15 plants (5 plants/subplot). Experiment was a split-plot design with maize lines as main plots and treatments as subplots, with three replicates of each plot.

*Significantly different from corresponding control at 5% level.

3) Plant spacing 85×30cm.

4) Data are means of three blocks.

七、選育中之超甜玉米品系對 MDMV-B 之反應

由表十統計分析之結果顯示，一般超甜玉米品種（系）對 MDMV-B 的反應較敏感，病毒感染

後，株高、莖軸、產量等均明顯受影響，而影響的程度在品種間亦有差異，M品系受影響的程度最大而異於其他品系，SD10, SH10×H 受影響的程度稍低於推廣的臺南15號和 Honey 236 ，但是未達顯著水準。

表10. B型玉米矮化嵌紋病毒感染對各個超甜玉米品種（系）生育之影響 [1]

Table 10. Effects of B strain of maize dwarf mosaic virus on developments and yields of different sweet corn varieties (lines).

玉米品系／品種 Corn lines/varieties	處理 Treat-ment	株高 (cm) Plant height	莖軸 (mm) Stalk diameter	單株鮮穗產量 Green ear yield (g/plant)	每公頃子粒產量 Dry grain yield (kg/ha.)	減產率 Yield loss% 鮮果穗 Green ear	減產率 Yield loss% 乾子粒 Dry grain
Tainan 15	I [2]	93.07 [3]	13.73	172.67	1,048.76 [4]	23.00 ab [5]	26.82 ab
	N	104.67	14.80	226.00**	1,421.16		
SD10	I	73.53	11.93	134.67	1,101.02	19.86 b	24.45 ab
	N	87.27	12.93	163.67*	1,473.95		
SH10×H	I	89.87	11.53	115.33	812.76	19.93 b	8.15 b
	N	96.00	12.47	145.33	979.45		
SH7×H	I	63.37	10.00	82.00	503.16	42.63 ab	55.43 a
	N	80.67*	11.87**	139.33**	1,093.67**		
SD7	I	69.87	12.13	126.00	994.17	28.24 ab	24.22 ab
	N	71.87	13.53*	176.67**	1,350.41		
M2	I	99.20	11.87	185.33	510.59	20.96 b	57.17 a
	N	117.33*	13.33*	238.00**	1,308.37**		
M	I	88.73	11.00	98.00	195.69	46.70 a	58.72 a
	N	106.53*	13.93**	187.33**	545.07		
BT2	I	97.60	13.00	128.00	555.82	34.57 ab	26.13 ab
	N	116.00*	14.13	196.67**	686.35		
Honey 236	I	87.40	13.90	161.67	1,248.80	22.89 ab	35.08 ab
	N	99.87	14.47	209.6 **	2,013.65**		
Mean	I	84.74	12.12	133.74	775.08	28.75	35.13
	N	97.80**	13.50**	187.52**	1209.23**		

1) Planted on September 20, 1988.
2) I : Inoculated with B strain of maize dwarf mosaic virus. N : Noninoculated.
3) Data are means of 15 plants (5 plants per subplot). Experiment was a split-plot design with corn entries as main plots and treatments as subplots, with three replicates of each plot.
*, **=Significantly different from corresponding control at 5% and 1% levels, respectively.
4) Plant spacing 85×30cm.
5) Data are means of three blocks, values in the column with same letters are not significantly different. (P=0.05)

討 論

雖然嵌紋病對玉米並不是一項會有立即而明顯危害的致命性病害，但是它並不全然對玉米的生育毫無影響[1,5]，因此如何正確地評估嵌紋病的效應以確認它的經濟重要性，這在防治策略的擬訂是相當重要的。 但是實際田間環境及生態條件等瞬息萬變， 並非短時間內簡單的田間試驗就能應付[8]；雖然如此，我們也不能等到所有外在因素都設定之後才開始試驗。本研究即逐步探討影響玉米生育的各個因素，首先依據流行病調查、病毒病原性測定、及經濟產量損失評估等三項結果，判斷 MDMV-B絕對是本省玉米嵌紋病的主要病原，而對症下藥展開系列試驗。其中設計田間試驗以評估 MDMV-B的影響時，發現所謂的病毒感染之直接效應及植株田間競爭的間接效應[15] 確實發生在一些案例上，造成估量時的複雜化；如實驗中不接種病毒的試區緊鄰已接種 MDMV-B 的試區時，供試植株在田間自然被傳染的機會增加（其比率因品種而異），但因隔鄰的病株生長勢較弱，試區內所有的植株反有較强的田間競爭力，此種因素必然會影響結果產量，但是整體而言如表五的平均值所示，這種安排的結果與完全隔離的不接種試區之對照並無顯著差異，倒是兩者的結果都明顯異於接種 MDMV-B 的試區，因此往後的試驗都只比較接種與不接種的結果，而省略其他的間效應。

評估玉米品種抗毒素病的特性時，必須先瞭解影響病毒感染及病勢發展的變異因子；而研究這些變異因子的方法及寄主反應的評估標準往往因人而異 ， 因此導致 結果的詮 釋也不 盡相同[16]。雖然 Louie[10] 已擬出標準化的接種步驟以評估不同遺傳型的玉米對 MDMV 的抵抗性，但是其中的許多變異源仍無法掌握，如環境溫度、同品種內植株的生長速率、植株的營養狀況、及接種的部位等，其能控制的因子僅有接種時植物的株齡、接種的重覆次數、每回接種的磨擦數、及接種源的濃度等。本研究遵照這些原則，在病害損失及品種效益評估時，均一致對供試植株接種 MDMV-B 兩次，結果都能使感病品種的接種試區之植株百分之百發病，如此已可對照出接種的效率，而在大規模田間試驗時省略其他接種的細節。此外，本研究的田間試驗部分， 其實驗設計與統計分析大抵上與 Madden et al[11] 所建議的方式吻合。

根據三年的試驗結果顯示，雖然栽培的環境與方法不同，已推廣的兩個玉米品種——臺南16號及臺農351號受 MDMV-B 感染後，子粒的產量損失都在20～29%之間，而 Honey 236 超甜玉米的鮮穗減產18～32%，子粒減產 35～37%，由此可知 MDMV-B 對目前玉米產業的影響力。新近推出的臺農一號雖然在第一年的試驗中表現極高的耐病力，其產量幾乎不因病毒感染而減少，但是後兩年的結果並不如此樂觀，其產量因 MDMV-B 感染而損失 17～20%，即使如此臺農一號受影響的程度仍然顯著低於其他供試品種，此項特點顯示其應用於田間對病害防治的經濟效益。

經由育種者以農藝的觀點選拔供作青割玉米的材料，其特性必然是莖葉生長勢特別旺盛，試驗中該批材料經吾人以溫室苗期法抗病篩選出具抗病性者，應用於田間經與感病品種對照，由表九之結果可明顯看出這些材料抗或耐 MDMV-B 的效益，其中株高（代表生長勢）受 MDMV-B 感染而減少的情況並不顯著，鮮穗及子粒產量所受的影響也不顯著仍然維持高產的特性（與臺南 5 號對照）。另外由育種者提供的超甜玉米材料，在溫室苗期抗病檢定即認爲全屬感病性，進行田間試驗的結果亦證實其生長與產量嚴重受 MDMV-B 的影響，因此亟需進一步改良目前超甜玉米族羣抗 MDMV-B 的能力。以雜交方式導入抗病基因於甜玉米品系中，雖然因會增加農藝性狀的瑕疵而不被育種者採用，但是國外仍有些現成的例子與材料[12,13,14]，値得參考採用。 無論如何， 超甜玉米新品系推廣之前應加以試驗，評估其對嵌紋病的反應，以避免推廣後遭受嵌紋病的猖獗爲害。

目前本省的玉米育種並未以抗病性爲首要目標，尤其對於病毒的抵抗性更被忽略，而事實上此種病害已普遍發生且上述的經濟影響力亦不容忽視，其防治之道唯有推廣種植抗病品種才確實有效，而國外已有相當的成果[5,9,12,13,14,16]，吾人針對國內的病害生態，從現有的玉米基因庫中篩選出一些抗病品系，以供進一步研究。由於即使同一遺傳型的抗病性在不同的環境所表現的結果也不一樣，因此從

溫室中篩選出來的抗病品系，到田間遭遇各種狀況是否仍然保持其抗病性；反之在溫室苗期表現感病的遺傳型，到田間是否全無可取之處；而欲命名的玉米品種要具何種程度的抗病性，在田間推廣才能避免產量的損失，這些都是亟待解決的問題。

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Influence of Corn Mosaic on Developments and Yields of Corn and Effectiveness of Resistance in Selected Lines to the Virus in the Field[1]

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Summary

B strain of maize dwarf mosaic virus (MDMV-B), strains A, B, D, and sourgrass of sugarcane mosaic virus (SCMV-A, -B, -D, -Sou), and undetermined isolate of SCMV (S-1) are all causal agents of corn mosaic in Taiwan. Investigating the occurrence of these viruses in 1983—1988 by ELISA, we found that MDMV-B was prevalent on corn producing areas of Taiwan. In the meanwhile MDMV-B is the main causal virus of corn mosaic was demonstrated by greenhouse seedling technique to determine the virulence of virus and field trials to estimate the yield losses of sweet corn inoculated with virus. Split-plot design was adopted for field experiments to evaluate the effects of MDMV-B on developments and yields of corn. The indirect effects of virus infection was not so significant that we only compared the difference between treatments of direct manual inoculation and noninoculation in the following experiments. Results of field trials in 1986—1988 showed that MDMV-B inoculation might severely reduce grain yield of inbred line "TA80—1410" up to 47.9%. Involved in this study two general released corn varieties ("Tainan 16" and "Tainung 351") reduced 22—29% grain yields and "Tainung 1" usually lose less and never more than 20% of yield indicated that "Tainung 1" was significantly less affected by MDMV-B than other tested varieties. Screening corn lines for resistance to MDMV-B in 1983—1989, we found that in a total of 2808 tested lines, 11 lines were resistant, 172 lines were moderately resistant, 324 inles were moderately susceptible, and remainders were all susceptible to the virus. Eight selected lines, which originated from silage corn and were not susceptible to MDMV-B, were evaluated for the effectiveness of their resistances in the field. No significant effects of MDMV-B on developments and yields of tested lines were observed indicated that this level of resistance is effective to prevent yield losses to the disease in the field. Plant heights, stalk diameters, and ear yields of seven breeding lines of sweet corn were significantly reduced due to inoculation with MDMV-B in the experiment, and these disease responses of every corn lines were significantly different.

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Anagrus incarnatus Haliday, a New Record from Eggs of Brown Planthopper in Taiwan[1]

Bing-huei Chen and Jih-zu Yu[2]

ABSTRACT

Anagrus incarnatus Haliday, an egg parasitoid of rice brown planthopper (BPH), is a new record from Taiwan. Its morphology was described and compared to *A. flaveolus* Waterhouse and *A. optabilis* (Perkins) which are the only two species of BPH egg parasitoids identified in Taiwan. Its biology was also studied and described.

Running head: Chen & Yu: Egg parasitoid of brown planthopper.

INTRODUCTION

The rice brown planthopper (BPH), *Nilaparvata lugens*(Stål)is the most serious insect pest of rice in Taiwan (Lin, 1974) and in most of Asia (IRRI, 1979). Its pest status is due to the resurgence after its natural enemies were killed by insecticide application (Heinrich, 1979), and its genetic variability to adapt to previously resistant rice cultivars (Pathak and Khush, 1979). Therefore, the natural enemies of BPH are its important controlling factors, and study on the utilization of these natural enemies in integrated pest management system becomes important. However, biological control of BPH has been overlooked for a long time under the pressure of over using chemicals. The effectiveness of the natural enemies in suppressing BPH is unable to reach its maximal potential because of the intensive application of insecticide in paddy fields. In Taiwan, farmers now are not willing to spray as frequently as usually because of low price of rice that makes them earn less profit for growing rice. This circumstance may create a favorable habitat for the activities of these natural enemies in rice paddy fields.

BPH has at least 16 species of parasitoids in Taiwan (Chiu, 1978). Among them, the egg parasitoid, *Anagrus* sp. which occupied up to 94% of occurrence is the most promising(Lin 1974). A. *flaveolus* Waterhouse and *A. optabilis*(Perkins) are the only two species have been identified (Miura et al. 1981, Sahad and Hirashima 1984). More species are believed remaining unidentified (Lin, personal communication). *A. incarnatus* Haliday has been reported existing in Europe (Britain, Denmark, Belgium) and Asia (Japan,

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Korea, Bangladesh) (Sahad and Hirashima, 1984). This paper describes *A. incarnatus* as a new record of BPH egg parasitoid in Taiwan and to compare with related species to facilitate its identification.

Anagrus incarnatus Haliday

Anagrus incarnatus Haliday, 1833, Ent. Mag., 1 : 347.

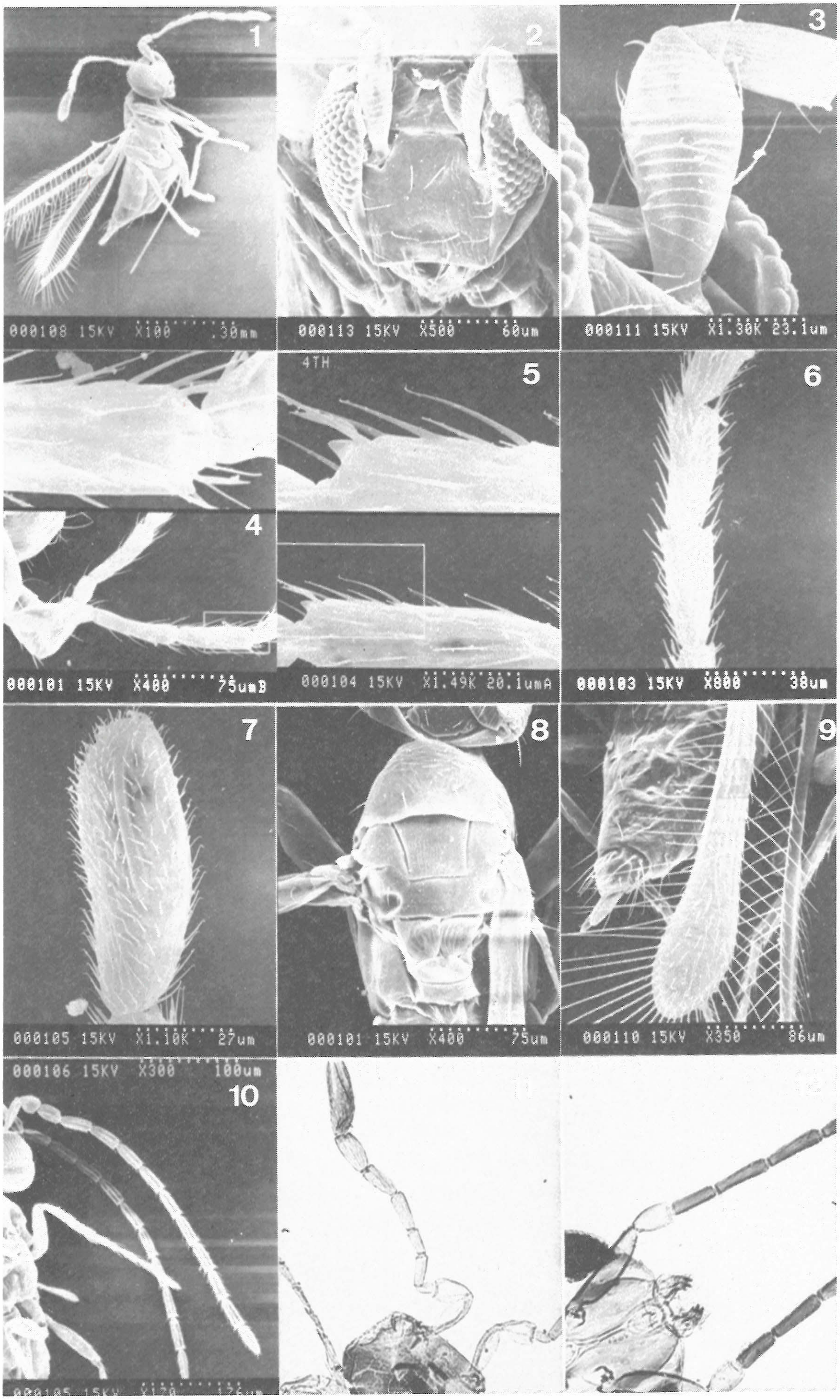
Anagrus incarnatus : Walkder, 1846, Ann. Mag. nat. Hist., 18 : 51.

Female (Fig. 1) : General color brownish orange; head, dark brown; antenna brown with scape, pedicel, 1st funicular segment light brown; eyes brownish red; mesonotum, propodeum pale yellow; wing transparent with marginal vein brownish.

Head subglobular, broader than thorax (Fig. 2); face slightly convex; gena large and elevated; OOL 3 times as long as POL; antennal torulus close to middle of inner margin of eye; scape stout, 3 times as long as wide, 2 times as long as pedicel, with 15—16 transverse lines (Fig. 3); pedicel pear-shaped, 1.5 times longer than wide, 2 times as long as 1st funicular segment; 1st funicular segment shortest, longer than wide; 2nd longest, 4 times as long as wide, gradually curved; 3rd shorter than 2nd but wider, with one sensory ridge (Fig. 4); 4th shorter but wider than 3rd, with one sensory ridge (Fig. 5); 5th and 6th gradually slightly shorter and wider than 3rd but each has two sensory ridges (Fig. 6); club with 4 sensory ridges, ovate (Fig. 7). Parapsidal furrow distinct (Fig. 8). Fore wing (Fig. 9) 9 times as long as wide, with 7—8 irregular lines of discal hairs distributed all over the broadest part of wing providing no bare space there; stigma with 4 circular sensilla compact closely at apex. Hind wing slightly shorter than fore wing with only one line of discal hairs along each margin, and very few hairs at middle of apex. Gaster longer than head and thorax together; ovipositor moderately exserted, exserted part about one-ninth as long as ovipositor.

Male: Generally similar to female, except in antennal structure (Fig. 10) and genitalia. Scape about 3 times as long as wide; pedicel subglobular, about one half as long as scape; 1st funicular segment longer than pedicel but shorter than remaining segments which each has 4 sensories and very similar to each other in length and width.

Biology: In the laboratory, this species has been reared as a solitary egg parasitoid of *N. lugens* cultured on rice plant. Adults usually emerge in the morning. Males that emerged earlier than females surrounded the emerging hole waiting the females for mating. Adult females therefore mated right after emergence and immediately search BPH eggs for oviposition. The way for female to search and probe BPH eggs is similar to that of the most of Hymenopterous parasitoids. It uses its antennae to detect the position of the host, and further identify if they are available or not. If the BPH eggs have not been parasitized, then it protrudes the oviposition duct to parasitize them. It takes 5—12 seconds to complete the process. In general, the female adult always skipps some BPH eggs in an egg mass without parasitizing. It takes about 13—16 days from egg to adult at 25±1°C. The adult longevity varies with temperature and is longer



Figs. 1—10. SEM photographs of *A. incarnatus*. (1) Adult body shape; lateral view. (2) Head; front view. (3) Scape with 15—16 transverse lines. (4) The 3rd, (5) The 4th, and (6) The 5th and 6th funicular segments. (7) Club. (8) Thorax in dorsal view. (9) Fore wing. (10) Male antennal segments. Fig. 11. Female antenna of *A. flaveolus*. Fig. 12. Scape of female *A. optabilis*.

when provided with honey and water. A famale adult is capable of parasitizing BPH eggs and producing up to 31 progenies with an average of 14. The sex ratio of the progenies emerged is about 2.51 : 1 for female : male.

Host : *Nilaparvata lugens* (Stål), *Nephotettix cincticeps* (Uhler), *Nagra nagaragawana* Matsumura, and *Sogatella furcifera* (Horvath) (Sahad and Hirashima 1984).

Distribution: Europe (Belgium, Britain, Denmark) and Asia (Bangladesh, Japan, Korea, Taiwan). This is the first record of this species from Taiwan.

Materials examined: Taipei, 9♀♀4♂♂, 27, V. 1970 (K. S. Lin); Taichung, 17♀♀ 3♂♂, 16, VII. 1976 (K. S. Lin); Wu-feng, Taichung, 33♀♀10♂♂, 2, IX. 1987 (B. H. Chen); Pingtung, 11♀♀3♂♂, 26, VI. 1970 (K. S. Lin).

Key to the species (famale) of *Anagrus* of Taiwan

1. First funicular segment appreciably long and cylindrical; scape without transverse lines (Fig. 11), second to 6th funicular segments equal or subequal; pedicel shorter than 1st funicular segment………………………………………………………*A. optabilis*

   First funicular segment very short, subglobular; scape with transverse lines (Fig. 3) ……………………………………………………………………………2

2. Third funicular segment without sensory ridge, shorter than 4th (Fig. 12); fore wing with 3 rows of discal hairs giving distinct small bare space at the broadest part…………………………………………………………………………*A. flaveolus*

   Third funicular segment with one sensory ridge(Fig. 4), longer than 4th; fore wing with 7—8 irregular rows of discal hairs providing no bare space at the broadest part (Fig. 9) ……………………………………………………………*A. incarnatus*

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Anagrus incarnatus Haliday 臺灣新記錄之褐飛蝨卵寄生蜂[1]

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摘 要

Anagrus incarnatus Haliday 爲水稻褐飛蝨之有效卵寄生蜂，係臺灣新記錄種，本文記述該種之形態與習性，並與臺灣已記錄之 *A. flaveolus* Waterhouse 與 *A. optabilis* (Perkins) 進行分類特徵之比較 *A. incarnatus* 每雌蜂最多可產卵31粒，平均約14粒，從卵到成蜂約需13—16天，雄蜂先羽化而出，再守在羽化孔，待雌蜂羽化時，立即交尾，雌蜂交尾後，即找尋褐飛蝨卵進行產卵寄生。

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Dodder Transmission and Microscopic Observations of Red-bird Cactus Witches' Broom Disease[1]

I-Lang Yang[2]

Abstract : The red-bird cactus witches' broom (RbWB) was transmitted from infected red-bird cactus to periwinkle by the dodder *Cuscuta chinensis* Lam. Free hand sections of RbWB infected periwinkle and red-bird cactus showed specific blue staining of Phloem cells with Dienes' stain under a light microscope, and specific bright fluorescence of phloem tissues under a reflecting fluorescence microscope. Similar sections from healthy plants gave no reaction, which indicated the presence or infections of mycoplasma-like organisms in the phloem tissues of infected plants. On periwinkle, red-bird cactus witches' broom induced a mild degree of bushy growth.

Introduction

Red-bird cactus witches' broom (RbWB) disease was recently found on red-bird cactus (*Pedilanthus tithymaloides* Poit.) in Taiwan [5] (Fig. 1). Electron microscopic studies provided evidence indicating a mycoplasmal etiology for the disease [5]. No other plants have been tested as possible new host. The periwinkle (*Vinca rosea* L.) seems worthy of such test for it has been shown susceptible to many plant mycoplasma-like organisms (MLOs) causing witches' broom symptoms [2,4,6,8,9]. The symptoms on periwinkle differed among the sources of withes' broom disease [9]. This study was attempted to see whether RbWB could be transmitted to periwinkle. The parasitic dodder plant, *Cuscuta chinensis* Lam., previously demonstrated to be capable of transmitting other witches' broom diseases , was used as vector [6,8,9]. We also made light and fluorescence microscopic observations for evidence of the presence of MLOs in the inoculated plant tissues [1,3,7,8].

Materials and Methods

Healthy red-bird cactus seedlings were raised in pots and were grafted with RbWB diseased scions for symptoms. Healthy dodder seedlings were established on healthy

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periwinkle plants and the branches of established dodder were later connected to RbWB diseased red-bird cactus. After two months , the connection was cut off. The periwinkle plants with dodder were maintained in green-house for one year, during which observations were made for RbWB symptoms [6,8,9]. Besides, free hand sections of stems and leaf veins of red-bird cactus and periwinkle were made of both RbWB diseased and healthy plants and observed under light microscope after treating with Dienes' stain [1,7,8], similar sections were also observed under refrecting fluorescence microscope (RFM, Zeiss Standard XBO-75W) after the method of Namba *et al.* (1981) [3].

Results and Discussion

The transmission test results showed that RbWB could be transmitted from a diseased red-bird cactus to a healthy periwinkle by dodder. Twenty-one out of 50 periwinkle plants bridged to diseased red-bird cactus by dodder developed RbWB symptoms (Table 1). The symptoms consisted mainly of a mild case of witches' broom appearance (Fig. 2).

Table 1. Transmission of red-bird cactus witches' broom from red-bird cactus to periwinkle by dodder.

Disease source	No. periwinkle plants tested	No. plants with disease	Days for disease development	
			Range	Av.
Diseased red-bird cactus	50	21	52—92	72
Healthy red-bird cactus	20	0		

The stem and leaf sections of the RbWB infected plants showed specific blue reaction with Dienes' stain in the phloem cells under a light microscope (Fig. 3), and specific yellow fluorescence in the phloem tissues under a reflecting fluorescence microscope (Fig. 4). No such reaction was observed in those of healthy plants. This indicated the presence of MLOs in the infected plants [1,3].

Acknowledgements

The author is indebted to Drs. M. J. Chen, E. Shikata, and H. J. Su for their support and help in this study, and also wish to thank Mr. T. C. Dang for his assistance in this experiment.

Explanation of plates

Fig. 1. The witches' broom-diseased plant of red-bird cactus showing bushy little leaves (A), and the healthy plant (B).

Fig. 2. The periwinkle infected with red-bird cactus witches' broom by dodder vector induced mild witches' broom symptom (A), and the healthy plant (B).

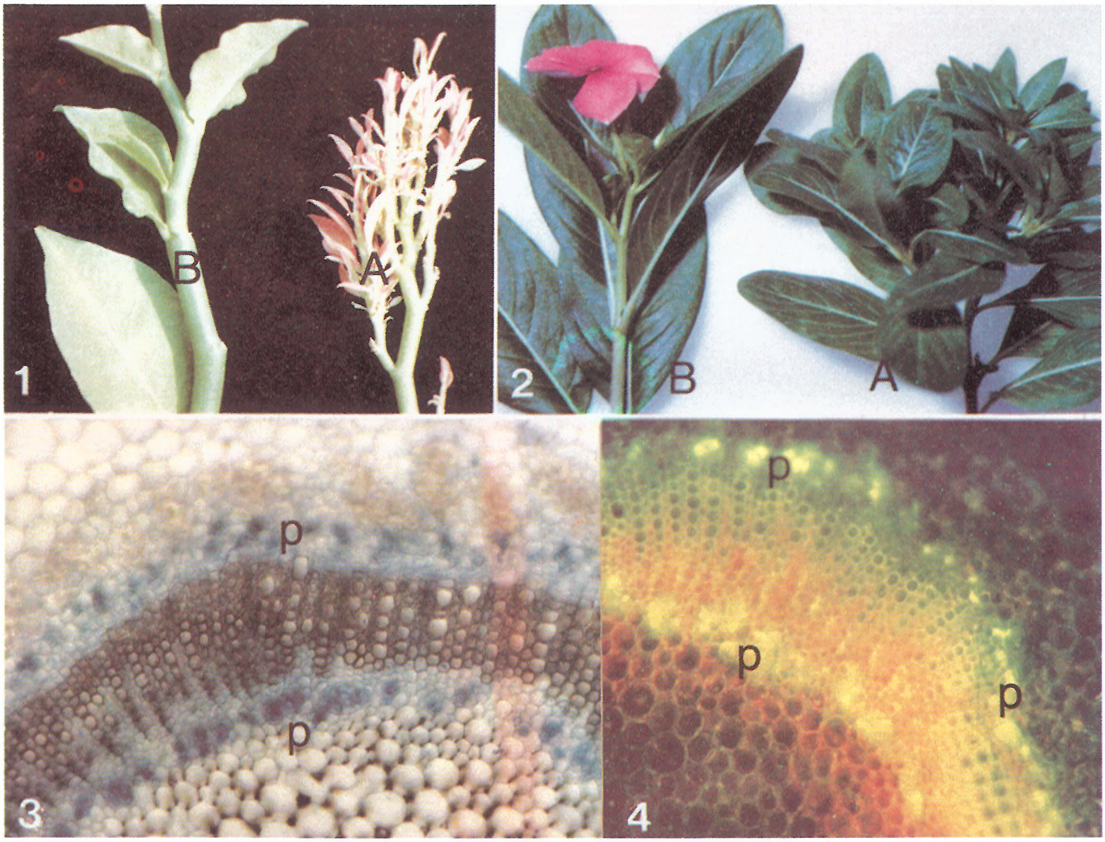

Fig. 3. Light micrograph of transverse section of witches' broom-diseased periwinkle stem treated with Dienes' stain, in which the phloem cells (p) stain distinctly blue.

Fig. 4. Fluorescence micrograph of transverse section of witches' broom-diseased periwinkle stem, in which the phloem tissue (p) show specific yellow fluorescence.

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青龍簇葉病之菟絲媒介傳染與顯微鏡觀察[1]

楊 一 郎[2]

摘 要

青龍簇葉病 (Red-bird cactus witches' broom) 可經菟絲 (*Cuscuta chinensis* Lam.) 媒介傳染而使長春草 (*Vinca rosea* L.) 感染罹病顯現葉化花之輕型叢生病徵。感染青龍簇葉病之長春草及青龍之病株切片，分別以經 Dienes' stain 處理後光學顯微鏡觀察及直接以反射型螢光顯微鏡觀察之結果，在其病組織篩管細胞分別顯現專一性藍色反應及特殊黃色螢光反應，對照健株則無此項反應，此項反應表示病株篩管組織中擬菌質病原之存在。

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香蕉挵蝶絨繭蜂之記錄[1]

周樑鎰[2]　蔣時賢[3]　黃明道[3]

摘要：本文將在臺灣飼育自香蕉挵蝶（*Erionota torus* Evans）幼蟲之香蕉挵蝶絨繭蜂（*Cotesia erionotae*（Wilkinson））分別和飼育自大白紋挵蝶（*Udaspes folus* Cramer）亦被鑑定爲香蕉挵蝶絨繭蜂之本地產寄生蜂與自夏威夷引進之香蕉挵蝶絨繭蜂比較外部形態性狀，結果顯示飼育自香蕉挵蝶者較接近於自夏威夷引進者。因此筆者等推測自夏威夷引進之香蕉挵蝶絨繭蜂已在臺灣立足。

香蕉挵蝶（*Erionota torus* Evans）於民國75年９月首先在屏東縣九如鄉發現，同年11月調查時，該蟲已廣泛地散佈於高屏各主要香蕉產區，至77年６月已成爲南部地區蕉園主要害蟲之一，並已擴散到嘉義梅山和臺東大武等地，蕉株受挵蝶爲害率平均在８％以下。夏威夷於1973至1974年自泰國與馬來西亞引進香蕉挵蝶絨繭蜂（*Cotesia erionotae*（Wilkinson））成功地防治尖翅香蕉挵蝶（*Erionota thrax*（Linnaeus））。因此筆者等亦進行香蕉挵蝶之生物防治研究。

民國76年５、６月間本文第一作者承農委會資助前往夏威夷研習生物防治有關之應用技術，復承夏威夷農部之協助得以在夏威夷歐胡島11處香蕉園採集尖翅香蕉挵蝶寄生蜂，於同年７月上旬將採得之香蕉挵蝶絨繭蜂攜回臺灣省農業試驗所天敵檢疫室檢疫並飼育，發現可寄生於香蕉挵蝶。後與香蕉研究所合作於民國76年７月在屏東縣之九如、里港及內埔分別釋放57、580及301隻香蕉挵蝶絨繭蜂。民國77年11月與78年３月香蕉研究所於九如自香蕉挵蝶幼蟲飼育得一種絨繭蜂，經鑑定爲香蕉挵蝶絨繭蜂。並發現飼育自香蕉挵蝶之絨繭蜂有兩種*Eurytoma*屬之重複寄生蜂。而本文第三作者於民國76年４月在屏東自爲害薑花之大白紋挵蝶（*Udaspes folus* Cramer）之幼蟲飼育得一種絨繭蜂，後經匈牙利自然歷史博物館Jeno Papp博士鑑定爲香蕉挵蝶絨繭蜂。

爲瞭解自香蕉挵蝶飼育而得之絨繭蜂是本地產之天敵或是引進之天敵立足之結果，將飼育自大白紋挵蝶與香蕉挵蝶幼蟲之絨繭蜂及自夏威夷引進之香蕉挵蝶絨繭蜂詳加比較，發現飼育自香蕉挵蝶者較接近於自夏威夷引進者。飼育自大白紋挵蝶之絨繭蜂，其小盾片（Scutellum）刻點及毛較密（圖４），腹部第一節背板之毛較疏，第二節背板側溝（Lateral sulci）較不明顯（圖１），側溝外側黑褐色、僅於邊緣黃褐色。而飼育自香蕉挵蝶與自夏威夷引進者小盾片刻點及毛較疏（圖５－６），第一節背板之毛較密，第二節背板側溝稍明顯（圖２，３），側溝外側黃褐色。因此筆者等推測自夏威夷引進之香蕉挵蝶絨繭蜂已在臺灣立足。

本研究承匈牙利自然歷史博物館Jeno Papp博士鑑定大白紋挵蝶之絨繭蜂學名，農試所林桂瑞先生鑑定重複寄生蜂學名；農委會資助部分經費（76—農建— 2.3—糧—130與76—農建—8.3—糧—01（９））；美國夏威夷農部賴博永博士及 Kenneth Teramoto 博士等協助在夏威夷採集香蕉挵蝶絨

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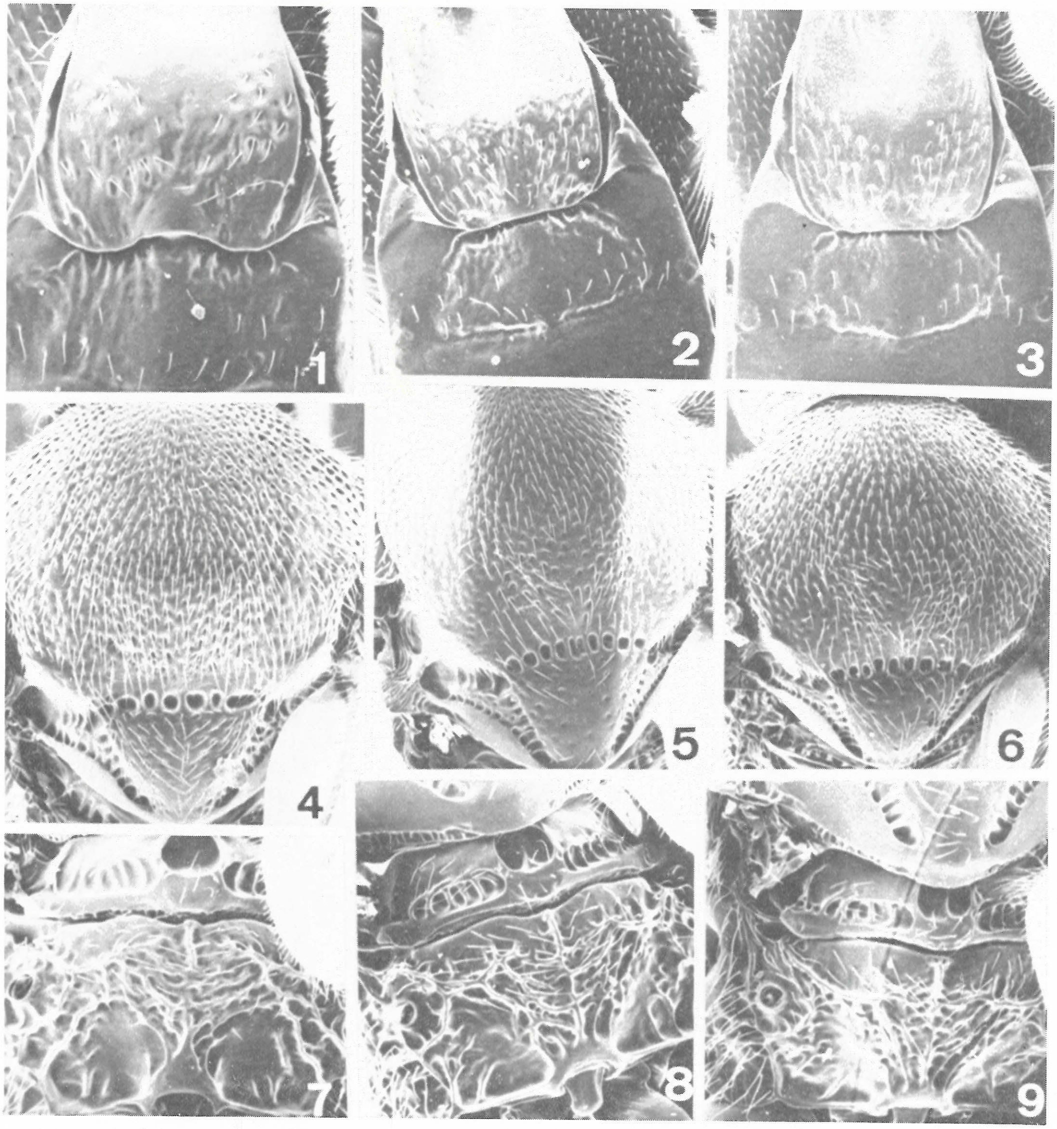
繭蜂；謹此致謝。



Figs. 1—9. *Cotesia erionotae* (Wilkinson) (Female): 1—3, first tergum; 4—6, mesonotums; 7—9, propodeums. 1, 4 & 7, specimen reared from *Udaspes folus* Cramer; 2, 5 & 8, specimen reared from *Erionota torus* Evans in Taiwan; 3, 6 & 9, specimen reared from *E. thrax* (Linnaeus) in Hawaii.

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The Discovery of *Cotesia erionotae* in Taiwan (Hymenoptera: Braconidae)[1]

Liang-Yih Chou[2], Hsih-Shin Chiang[3] and Ming-Tao Hwang[3]

Summary

To control the banana skipper, *Erionota torus* Evans, the braconid parasitoid of *E. thrax* (Linnaeus), *Cotesia erionotae* (Wilkinson), was introduced from Hawaii, and released in July, 1987. Meanwhile, a native braconid was found parasitizing in *Udaspes folus* Cramer (Hesperiidae) on ginger lily. Since this parasitoid was later identified as *C. erionotae*, a comparision on morphological characters was made. Results revealed that they differ slightly in the punctures and/or hairs of scutellum and first tergum, and the coloration of second tergum. In November, 1988 and March, 1989, larvae of *E. torus* collected from banana farm at Chiuju, Pingtung, Taiwan were found to be infested by *C. erionotae*. The morphological characters of this parasitoid were similar to those that introduced from Hawaii. Therefore, we suggest that the *C. erionotae* introduced from Hawaii has established in Taiwan.

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